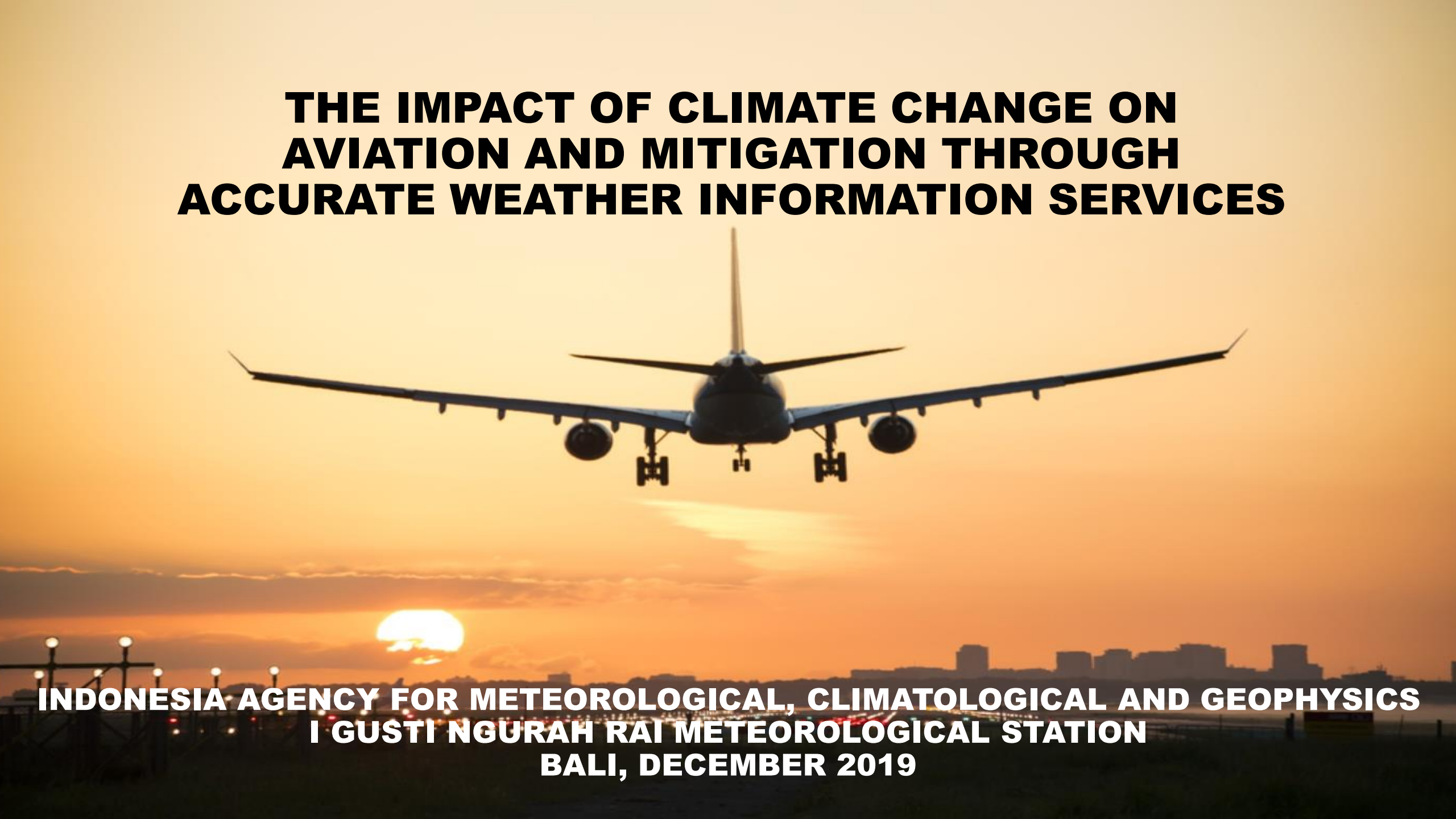
THE IMPACT OF CLIMATE CHANGE ON AVIATION AND MITIGATION THROUGH ACCURATE WEATHER INFORMATION SERVICES



INDONESIA AGENCY FOR METEOROLOGICAL, CLIMATOLOGICAL AND GEOPHYSICS
I GUSTI NGURAH RAI METEOROLOGICAL STATION
BALI, DECEMBER 2019

OUTLINE

I. CLIMATE CHANGE AND AVIATION
II. CLIMATE CHANGE IMPACT ON AVIATION
III. METEOROLOGICAL SERVICES
IV. METEOROLOGICAL EQUIPMENT

CLIMATE CHANGE AND AVIATION

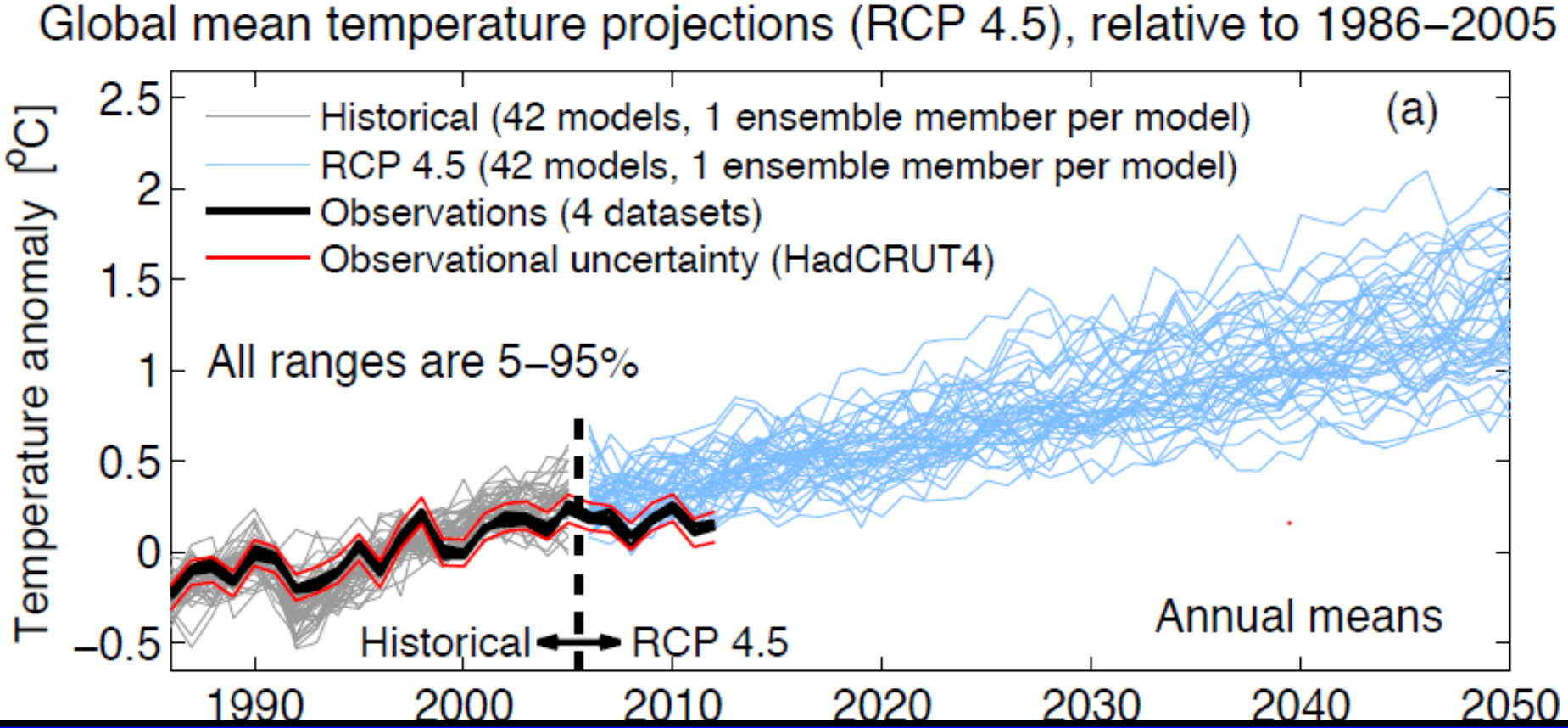
NOT ONLY

AVITION IMPACT ON CLIMATE CHANGE

BUT ALSO

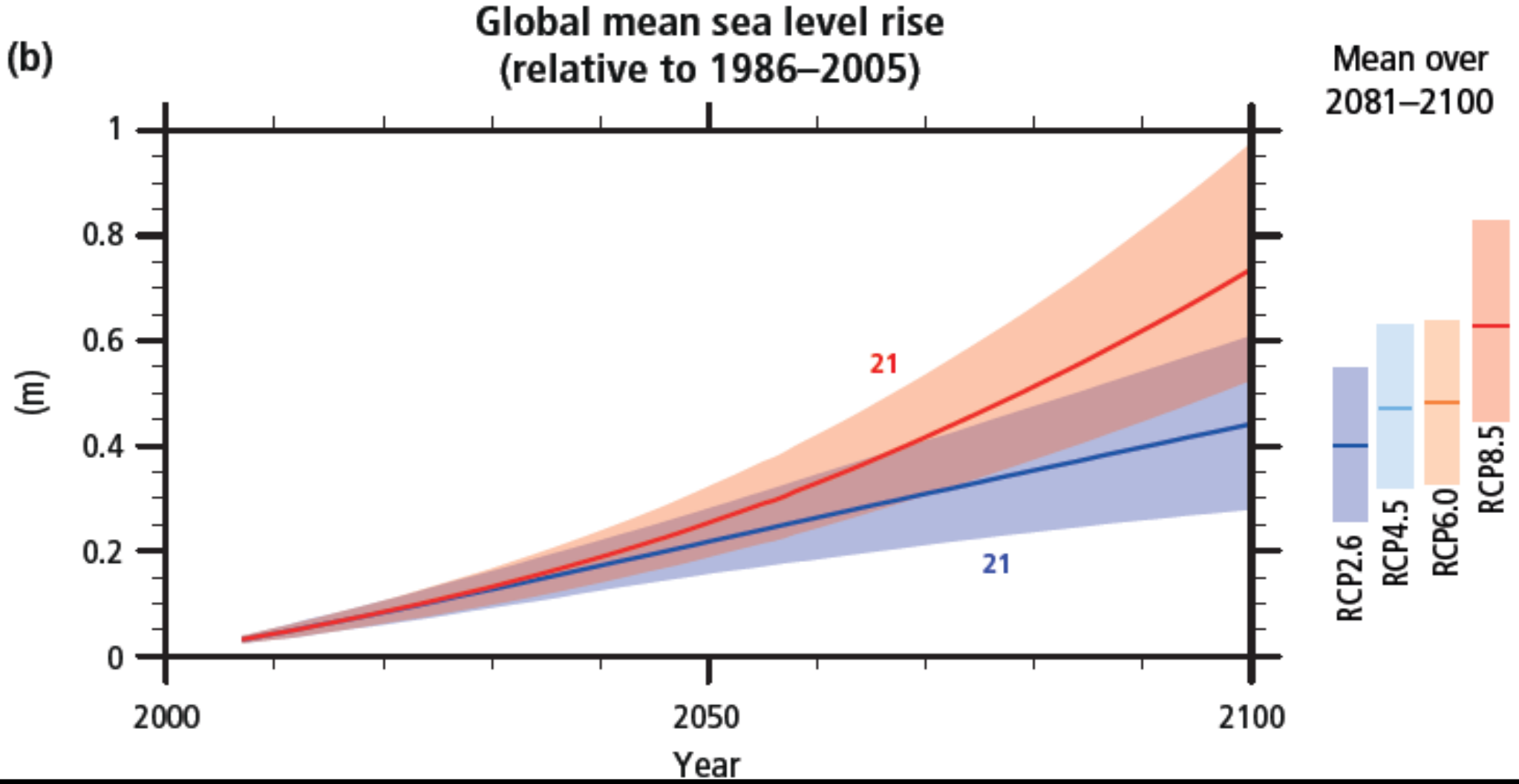
CLIMATE CHANGE IMPACT ON AVIATION

CLIMATE CHANGE



Projections of global mean, annual mean surface air temperature 1986–2050 (anomalies relative to 1986–2005) under RCP4.5 from CMIP5 models (blue lines, one ensemble member per model), with four observational estimates: HadCRUT3: Brohan et al., 2006 ;ECMWF interim reanalysis of the global atmosphere and surface conditions (ERA-Interim: Simmons et al., 2010 ;GISTEMP: Hansen et al., 2010; NOAA: Smith et al. (2008) for the period 1986–2011 (black lines). Intergovernmental Panel on Climate Change (IPCC), 2016

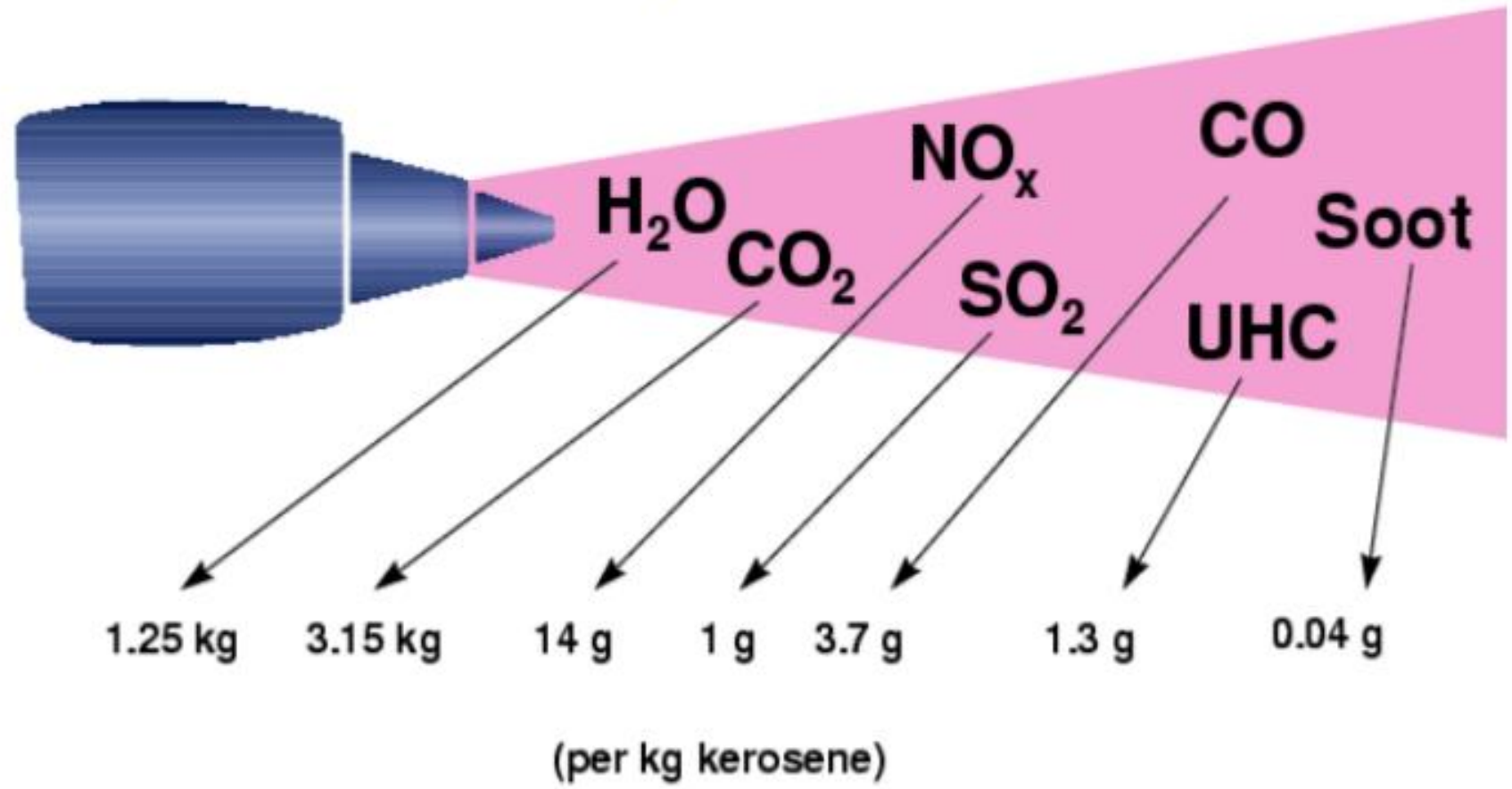
CLIMATE CHANGE



The projection show that for next 5 years Global Mean Sea Level Rise by 0.1 - 0.15 m.
Sources: Intergovernmental Panel on Climate Change, 2016

CLIMATE CHANGE AND AVIATION

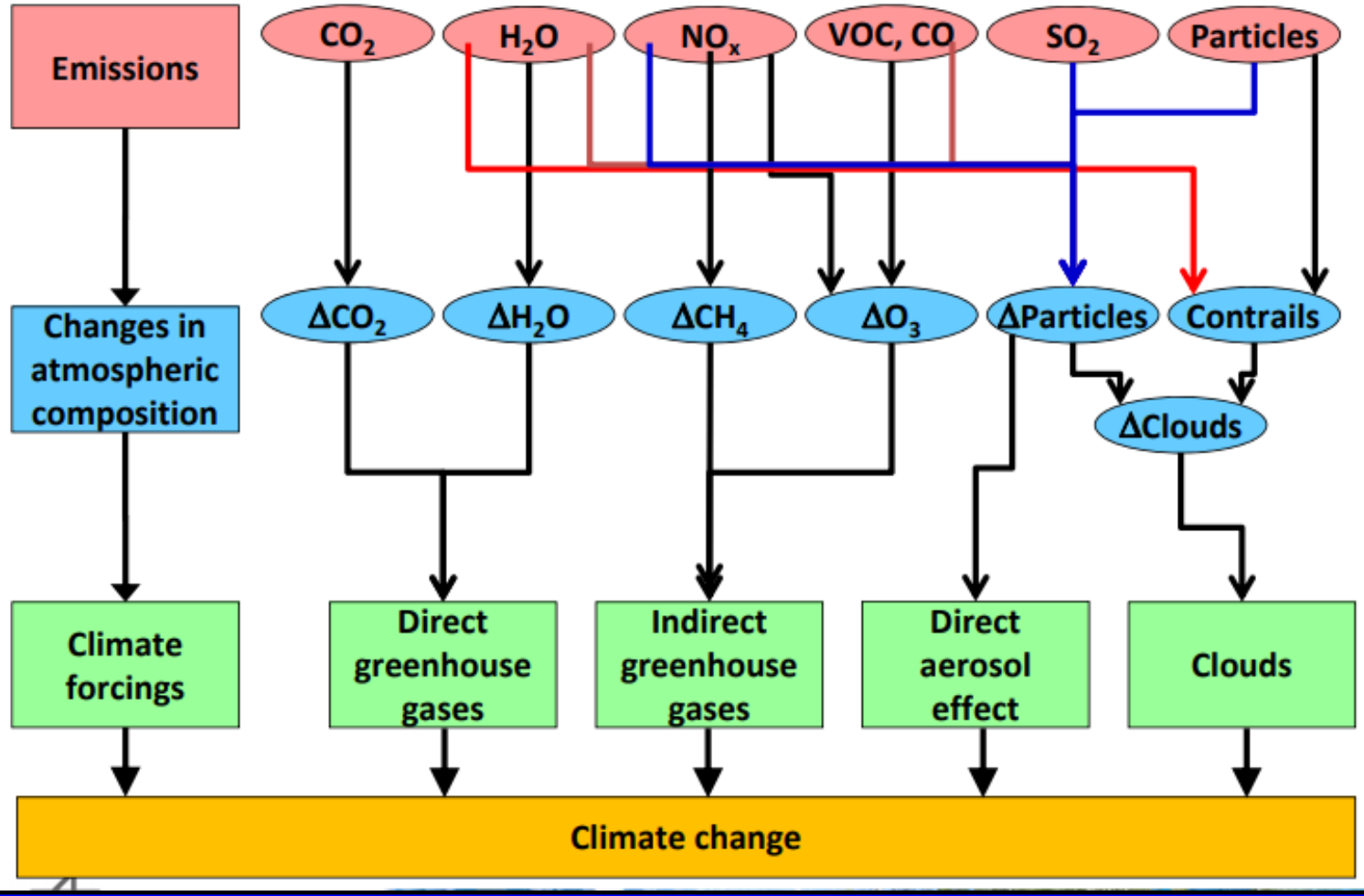
AIR TRAFFIC EMMISIONS AT CRUISE



Per Kg Karosene will turn into 6 emmisions i.e. water, carbon dioxide, nitrogen oxide, unburn hidrocarbon, Sulfur dioxide and Carbon monoxide. Combustion products depending on operating conditions at cruise altitude. Sources: V. Grewe, 2018

CLIMATE CHANGE AND AVIATION

ATMOSPHERIC EFFECTS OF AVIATION

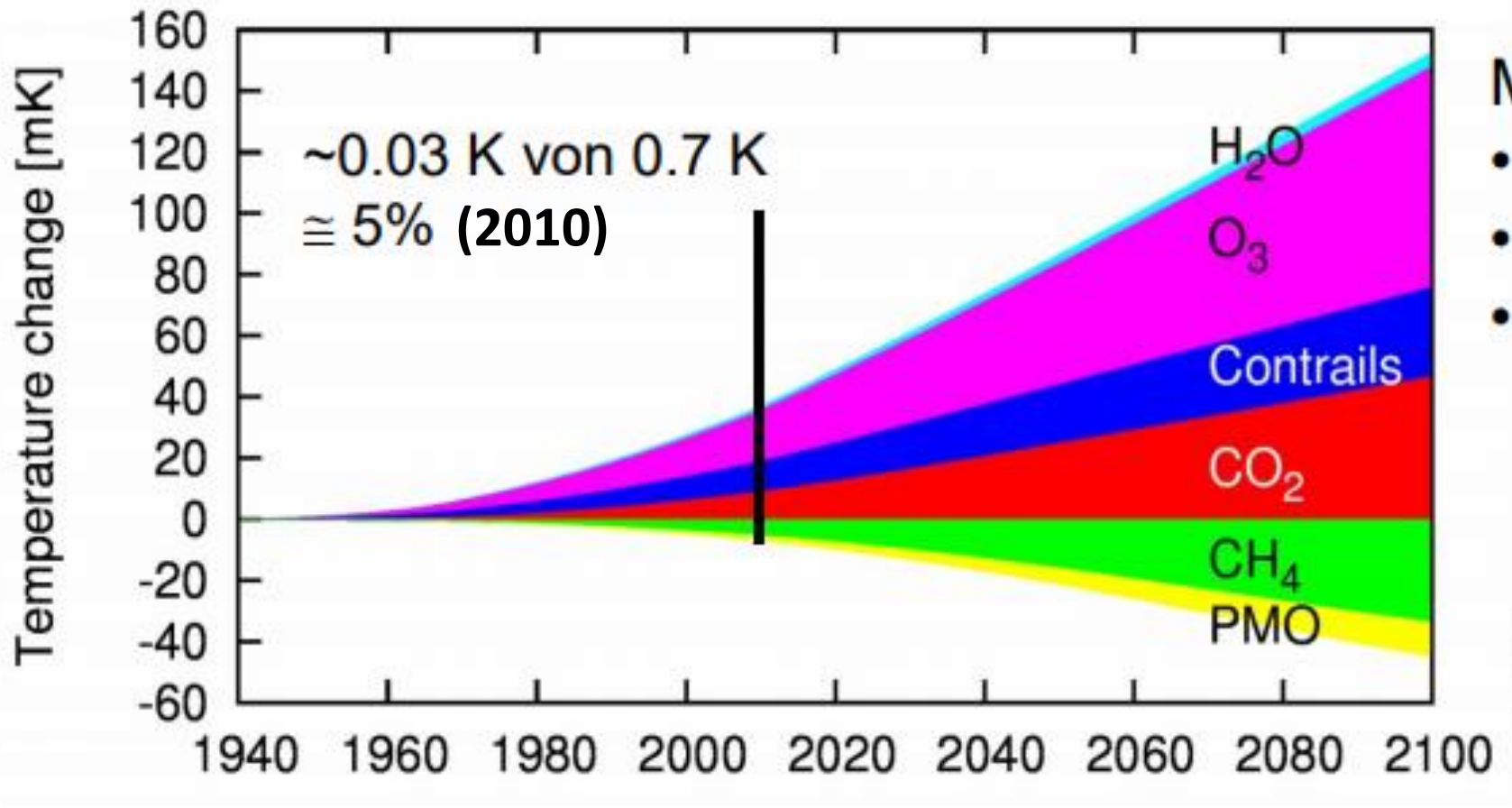


Aircraft emissions cause changes in composition of the atmosphere and climate forcing. Composition of atmosphere that will changes are Carbon dioxide, Water, Metana, Ozone and Clouds.

Sources: V. Grewe, 2018

CLIMATE CHANGE AND AVIATION

AVIATION'S IMPACT ON GLOBAL MEAN 2 M-TEMPERATURE



Main contributors :

- CO_2
- Contrails
- NO_x (O_3 and CH_4)

PMO=„Primary mode ozone“
Results from less CH_4
⇒ less HO_2 ⇒ less O_3 production

The Projection shows that Air traffic cause Global Mean 2 M-Temperature changes by 0.04-0.05 K for next five years. Air traffic contribute to climate change by roughly 7%

Sources: V. Grewe, 2018

CLIMATE CHANGE IMPACT ON AVIATION

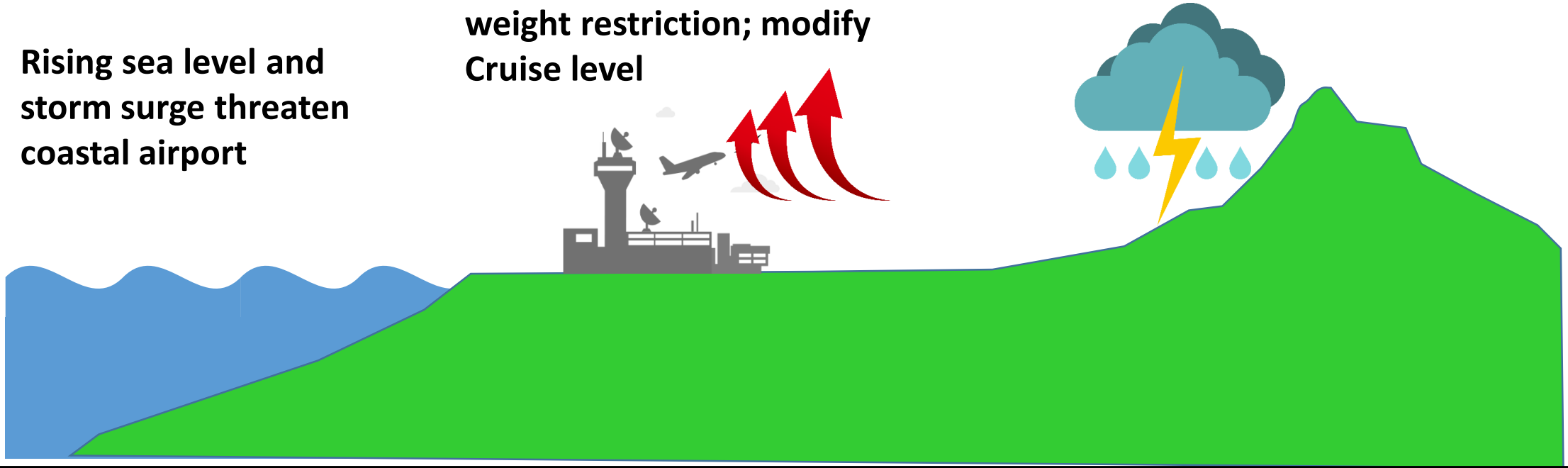
Shifting wind pattern → change optimal flight route and fuel compsumtion

Stronger Jet-Strem → Stronger Clear Air Turbulence

Increasing extreme weather event, wind shear → disruption and delay in air transport services

Warmer air → reduce take-off weight restriction; modify Cruise level

Rising sea level and storm surge threaten coastal airport



Sources: Puempel and Williams (2016), ICAO Enviromental Report

IMPACTS ON AIRCRAFT OPERATORS

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PHYSICAL RISKS

- Infrastructure damage caused by flood, sea level rising, severe storm, heavy rain and others extreme weather events;
- Runway buckling and material deformation caused by temperature increased.

BUSINESS RISKS

- Reduced capacity, en-route capacity and transportation access on land due to rising sea levels;
- Route extension, due to increased convective weather;
- Delay or flight cancellation due to bad weather, wind shear, cross wind;
- Decreased number of passengers.

SECURITY RISKS

- Threat on life and safety (Storms, Lightning, Security Scanner Interruption, turbulence) ;
- Increased of Jet stream→ increasing of en-route turbulence.

ENVIRONMENTAL RISKS

- Employs Health;
- Water crisis;
- Environmental changes.

Source: Baglin, C. (n.d.). ACRP Synthesis: Airport Climate Adaptation and Resilience (Rep. No. 33). National Academies Press. EurocontrolEuropean Aviation in 2040 Challenges of Growth Annex 2: Adapting Aviation to Changing Climate

COLLABORATION

AIRPORT

- Need to be resilience against local disruptions

ATM

- Need flexibility to operational changes

AIRLINES

- Vulnerable to operational disruptions depending on airports and ATM
- Need to ensure customers' satisfaction

GOVERNMENT

- Providing Regulation, Risk Assessment Plant, **METEOROLOIGCAL** information dan Warning
- Insurance to work together

Sources: IATA, 2019

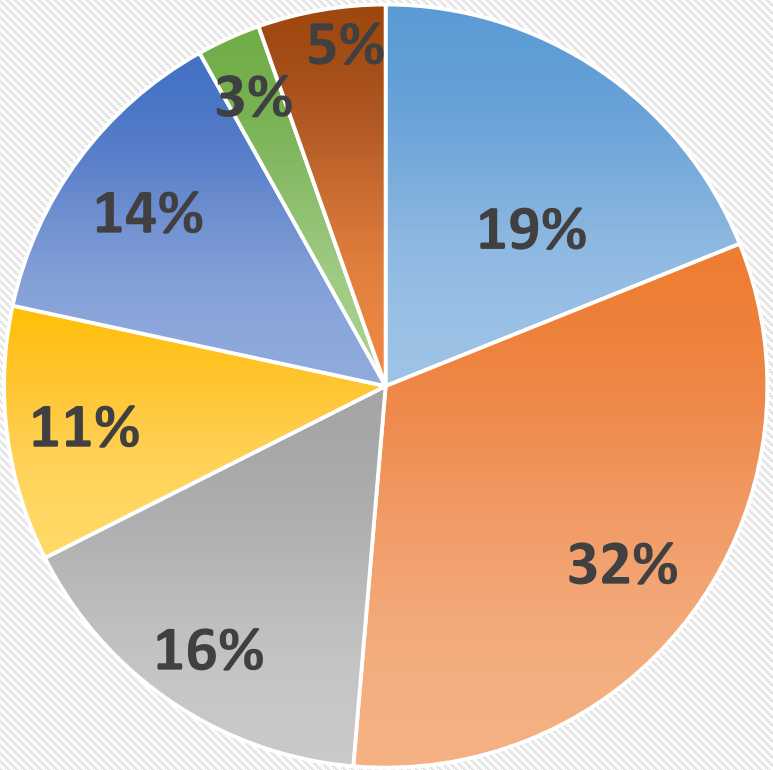
QUESTIONNAIRE CLIMATE CHANGE AND AVIATION

BMKG

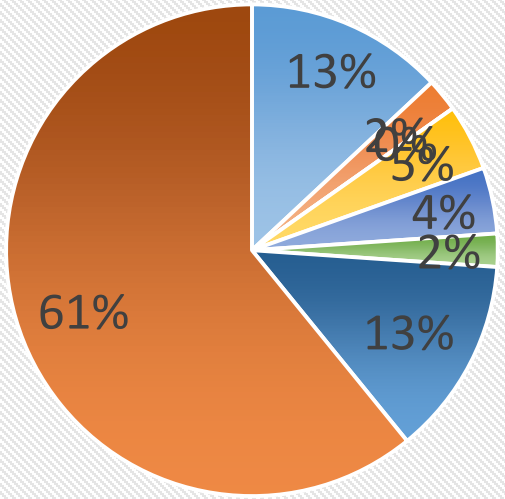
There are 5 main topic i.e.
Airport Infrastructure and Performance (1-6);
Flight Safety (7-9);
Airport Operations and Performance (10-13);
Air Traffic Management (14-15) and
AIrline Operation (16-20).

1	Heat damage to runway surface in more frequent extreme temperature events
2	Higher chance of airfield flooding due to heavy rain
3	Higher chance of airfield flooding due to storm surge
4	Drainage of runways, taxiways, apron areas need to be improved
5	Ground subsidence
6	Adaptation to changed cooling and heating requirement on facilities
7	Increased risk of bird strike due to changes in bird migration patterns
8	Presence of strong low level temperature inversion affecting aircraft performance during take-off / landing
9	Increased severity and frequency of clear-air-turbulence
10	Increased noise problem due to shallower climbs or choice of runway due to shift of wind pattern
11	Longer take-off and landing distances in a warming climate
12	Reduced runway capacity due to higher runway occupancy times
13	Reduced aircraft movements due to ground operation at high temperatures
14	Increased challenge in managing terminal area capacity due to increased risk of thunderstorms
15	Increased impact on low visibility operation due to chnages in fog/haze/mist occurrence
16	Increased fuel consumption due to- more APU (auxiliary power unit) usage during the turnaround
17	Increased fuel consumption due to longer routing due to thunderstorms and clear air turbulence
18	Increased fuel consumption due to slower cruising speeds
19	Reduced payload in warmer climate
20	More frequent disruption to operation due to extreme events (storm, snow etc.)

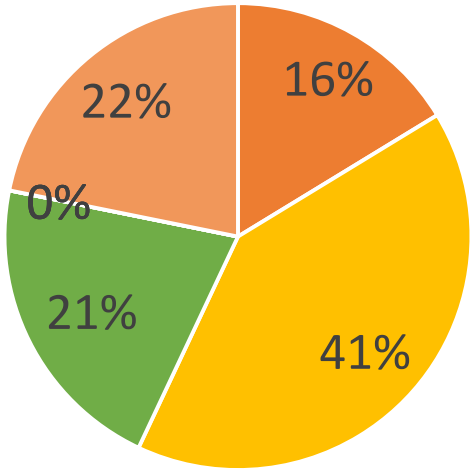
SURVEY REPORT



- Administration and Governance
- Pilot
- Air Traffic Services
- Airline Operator (dispatch / flight operation center)
- Airport Operator
- Ground Handling Operator
- Airframe and Engine Manufacturer / Maintenance company



- AUSTRALIA
- EUROPE
- INDIAN OCEA
- MIDDLE EAST
- NORTHEAST ASIA
- PACIFIC
- SOUTH ASIA
- SOUTHEAST ASIA



- N. Hemisphere
- S. Hemisphere
- Tropics
- Mid-latitudes
- Arctic/Antarctic
- Coastal
- High altitude

Survey of 37 correspondents
32% are pilot
61% are relevant with en route on Southeast Asia
41% are relevant with aerodrome on S. Hemisphere

SURVEY REPORT

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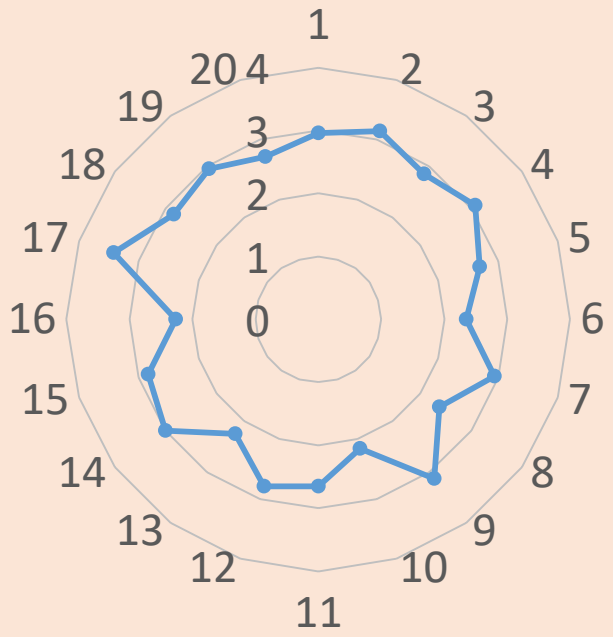
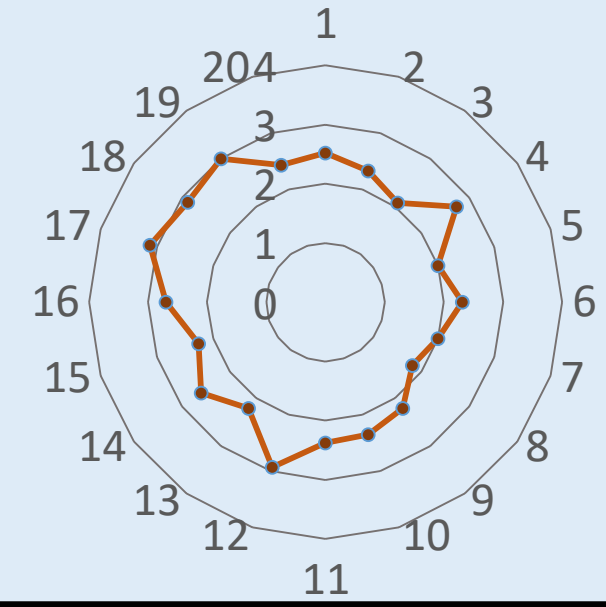
SEVERITY



PROBABILITY



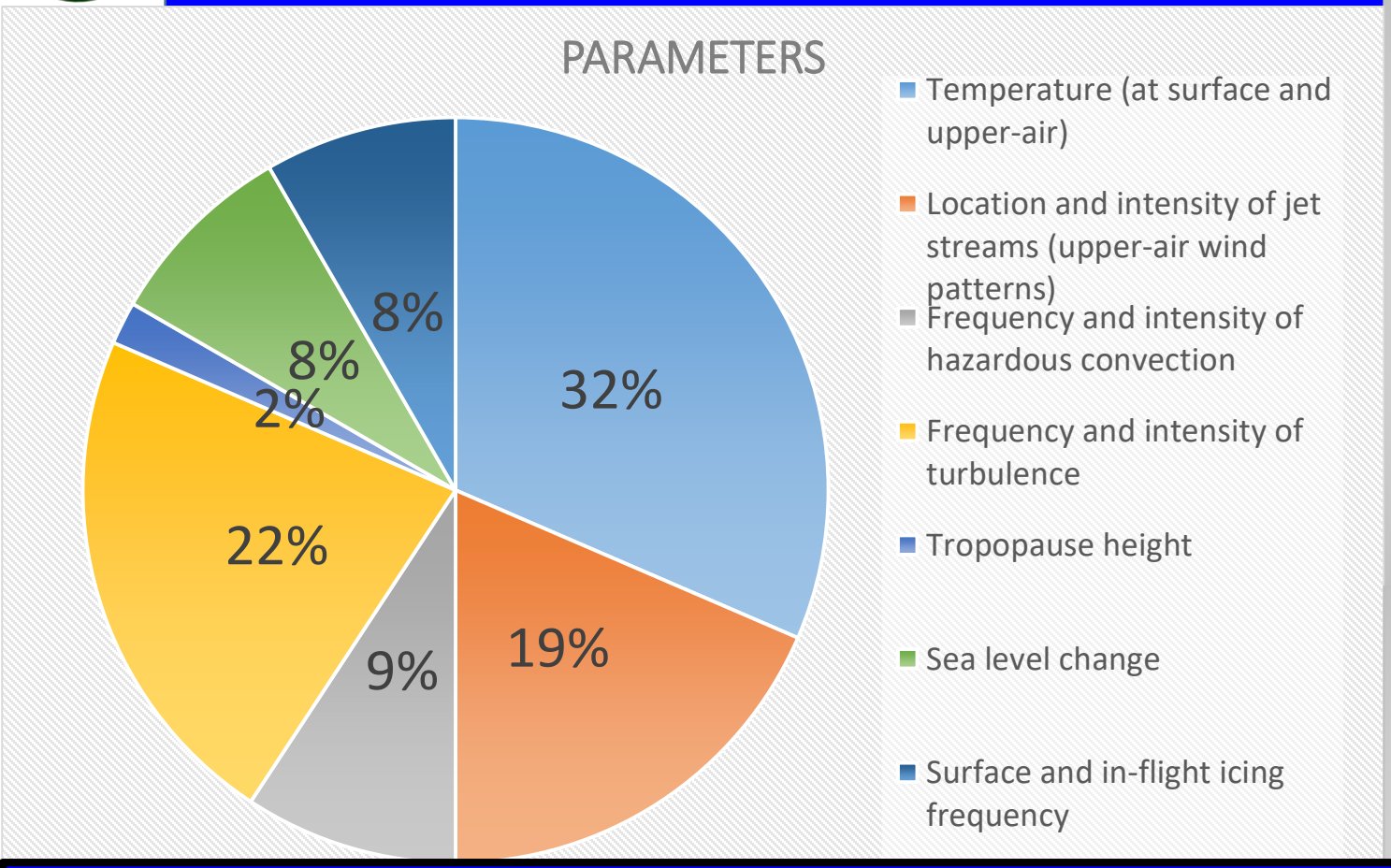
Based on severity result (1 being very low and 5 very high)

- the highest score for Increased fuel consumption due to longer routing due to thunderstorms and clear air turbulence (17) --> means respondents ***believe that this event most dangerous to aviation that caused by Climate Change***
- the lowest score for Increased noise problem due to shallower climbs or choice of runway due to shift of wind pattern (10)

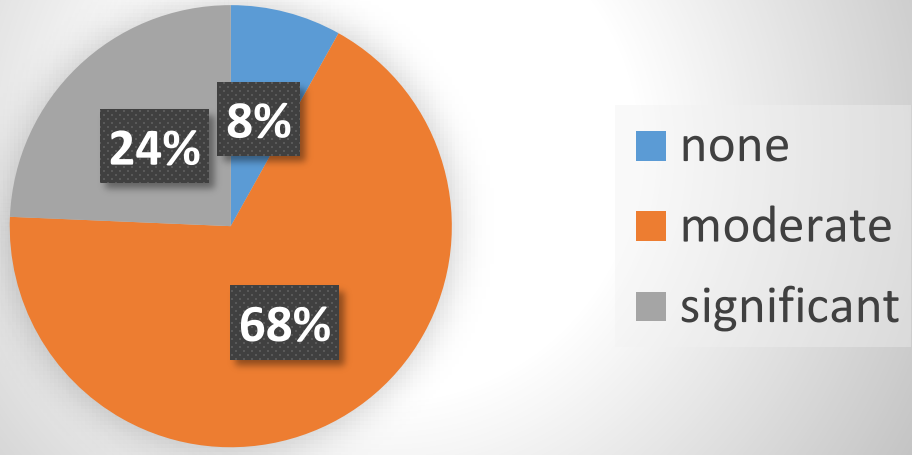
Based on probability result (1 being very unlikely and 5 very likely)

- the highest score for Increased fuel consumption due to longer routing due to thunderstorms and clear air turbulence (17) --> means respondents ***believe that this event will often happen that caused by Climate Change***
- the lowest score for Presence of strong low level temperature inversion affecting aircraft performance during take-off / landing (8)

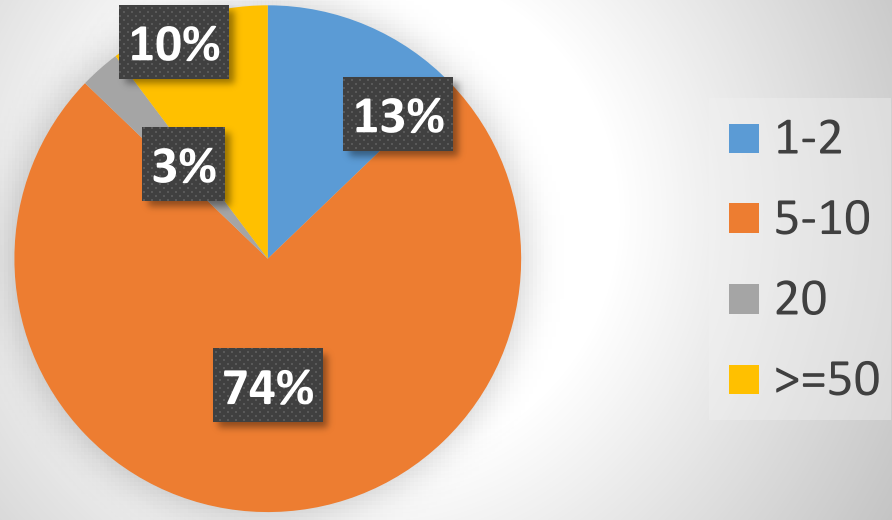
SURVEY REPORT



DEGRE OF IMPACT OF FUTURE CLIMATE CHANGE ON AVIATION



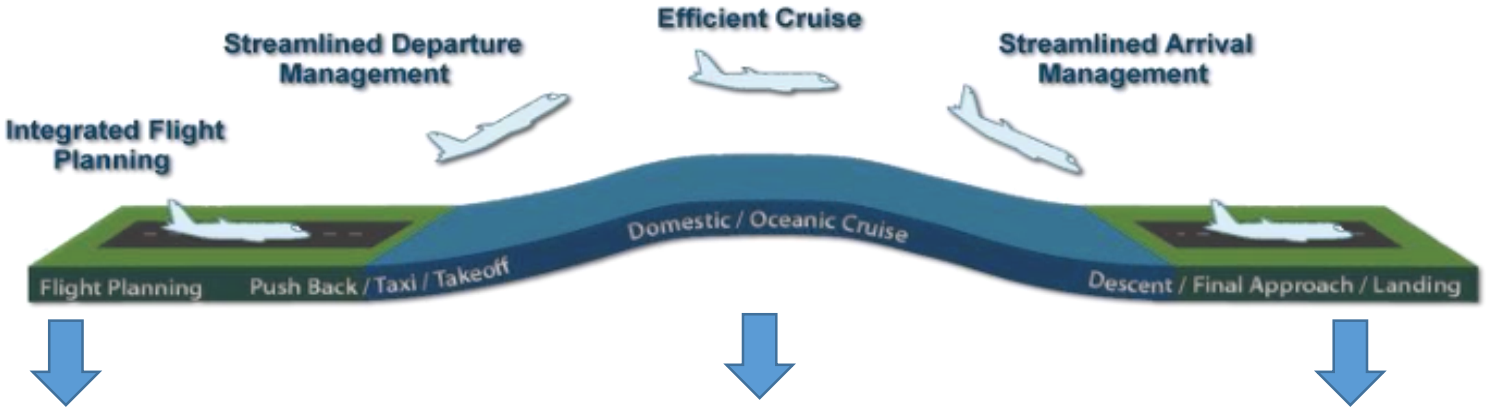
YEARS



68% respondents believe that degre of impact are moderate
32% respondents believe that parameters Temperature (at surface and upper air) are the most important change
74% respondents believe that 5-10 years are the period of CC may effect aviation

MITIGATION THROUGH METEOROLOGICAL INFORMATION

AVIATION METEOROLOGICAL SERVICES



Operational MET Data

- **Routine Report:**
  - Met Report
  - METAR
- **Special Report:**
  - SPECI
  - SPECIAL
- **Pre-flight Met Briefing:**
  - Weather Synopsis
  - Avi Met Bulletin
  - Satellite/Radar image

- **Flight Document**
  - Upper air, wind temp Chart
  - Significant weather chart
  - Aerodrome Forecast
  - Met Satellite

- **Aerodrome Forecast**
- **Aerodrome / Wind Shear Warning**
- **Volcanic Ash Warning**
- **Aerodrome Climatological Summary**
- **Public Meteorological Service**

WEATHER INFORMATION SERVICES
TO MITIGATE CLIMATE CHANGE IMPACT ON AVIATION

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- Aerodrome Forecast
- Aerodrome / Wind Shear Warning
- Volcanic Ash Warning
- Aerodrome Climatological Summary
- Public Meteorological Service

- Routine Report:
  - Met Report
  - METAR
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  - SPECIAL
- Pr-flight Met Briefing:
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- Aerodrome / Wind Shear Warning
- Volcanic Ash Warning

- Aerodrome Climatological Summary
- Public Meteorological Service
- Avi Met Bulletin

METEOROLOGICAL INSTRUMENT

- AWOS
- Synergie System
- Doppler Weather Radar
- Portable Weather Station
- Theodolite & Rason
- Weather Display
- Weather model
- Wind Profiler
- LIDAR



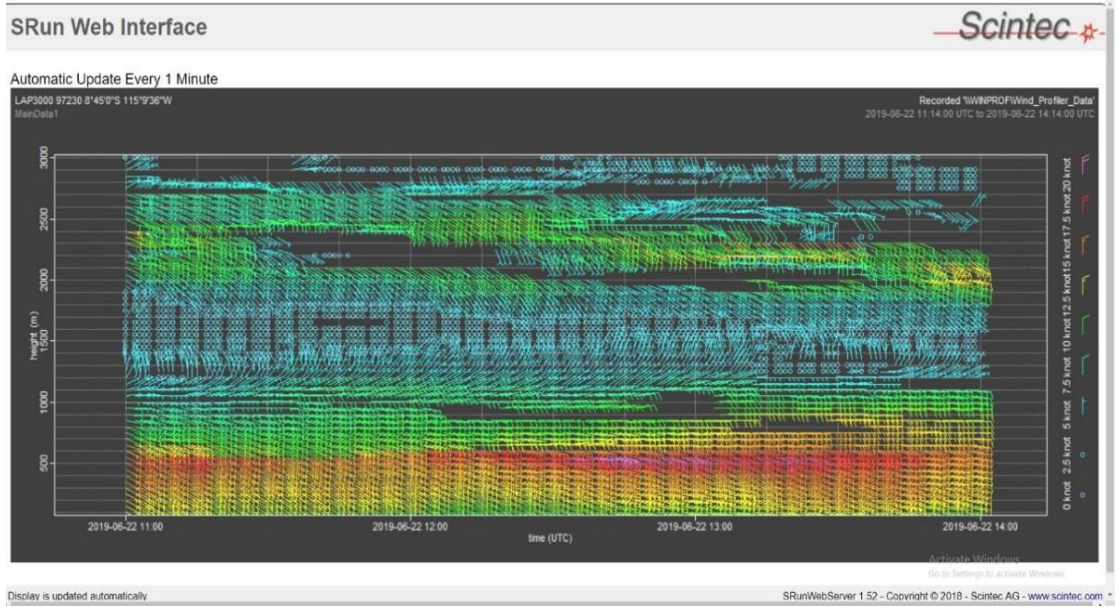







WIND PROFILER

WIND PROFILER RADAR LAP 3000



Principle
Electromagnetic Scattering→heterogen atmosfer
→ Doppler analysis of reflected waves scattering signals in the atmosphere
(Scintec, 2019).

WIND PROFILER

ADVANTAGES

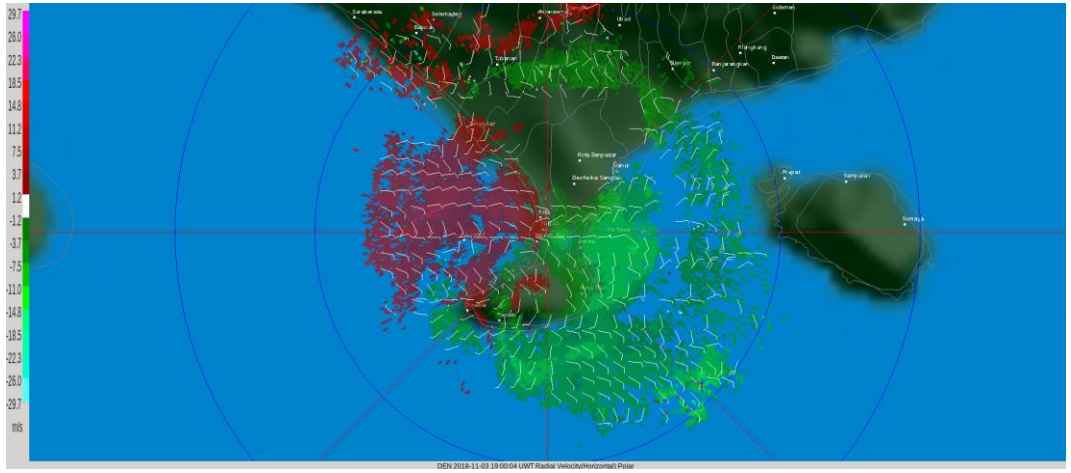
- Realtime scanning every 3 minutes;
- Temperature information for each layer
- Warning and Alert
- User friendly and big data storage

DISADVANTAGES

- Maximum height only + -3000 m;
- Scanning is not optimal during the bad weather event and there are many cover of low clouds, therefore doppler weather radar still requaired

DOPPLER WEATHER RADAR

BMKG



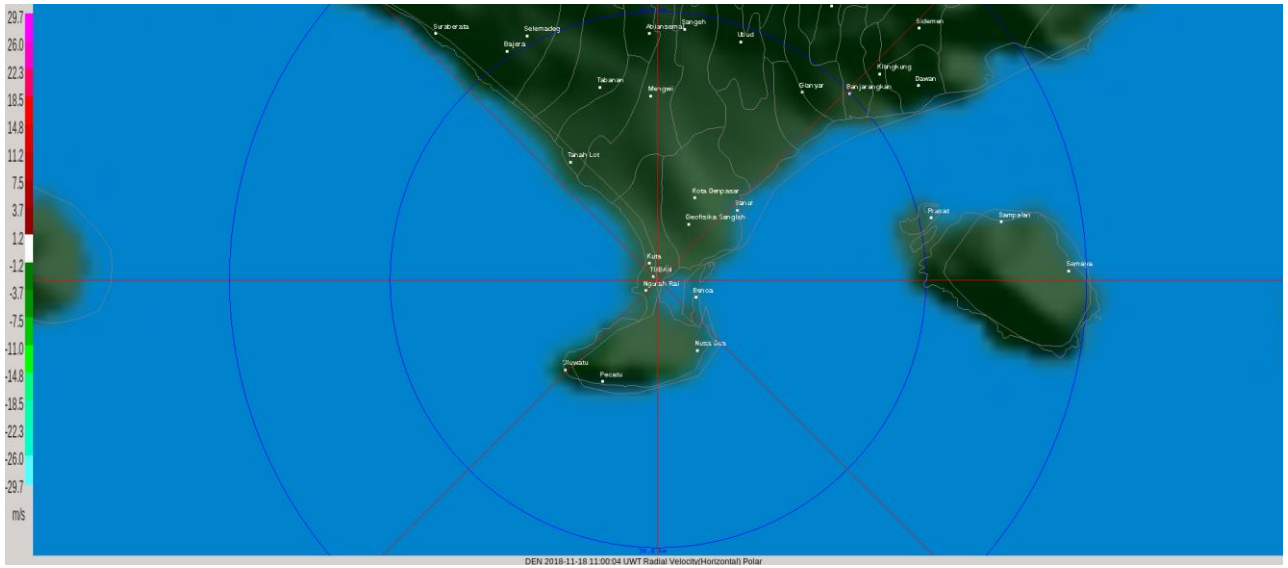
Universal Wind Technique (UWT) can be used to detect windshear

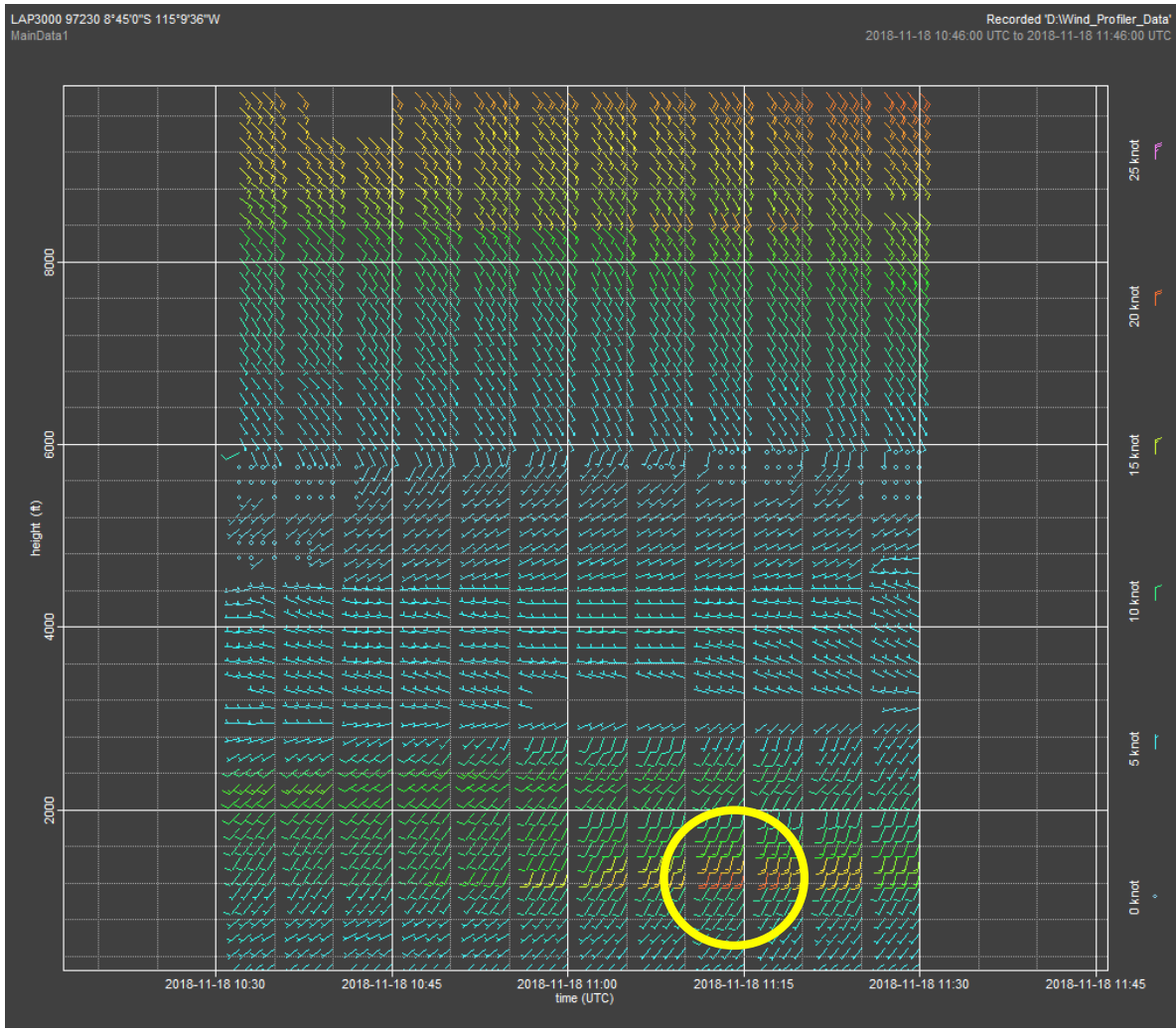
BMKG

WINDSHEAR EVENTS

NO	DATE	TIME (UTC)	WEATHER	CLOUD	WP	RADAR
1	3-Nov-18	19,00 UTC	+TSRA	FEW013CB BKN013	+	+
2	4-Nov-18	14.36	TSRA	FEW010CB BKN010	+	+
3	7-Nov-18	14.09	TSRA	FEW014CB BKN015	+	+
4	11-Nov-18	20,30	GUSTY	BKN010	+	+
5	14-Nov-18	19,40	+TSRA	FEW014CB BKN015	+	+
6	28-Nov-18	15,30	+TSRA	FEW015CB BKN016	-	+
7	1-Nov-18	03,10 (03,05)	NILL	FEW017	+	-
8	7-Nov-18	09,45 (09,40)	NIL	FEW015CB SCT016	+	+ (09,40)
9	18-Nov-18	11,00 (11,15)	NILL	FEW017	+	-
10	24-Nov-18	12,00 (12,15)	RA	BKN013	+	+ (12,00)
11	25-Nov-18	17,19 (17,20)	RA	FEW014CB BKN015	+	+ (17,30)
12	26-Nov-18	02,38 (02,30)	NILL	FEW017	+	-
13	27-Nov-18	01,21 (01,30)	NILL	FEW017	+	-
14	27-Nov-18	02,26 (00,00)	NILL	FEW017	+	-
15	6-Dec-18	18,50	+TSRA	BKN010 FEW013CB	+	+
16	22-Dec-18	07,00	+TSRA	BKN012 FEW014CB	-	+
17	3-Dec-18	09,30 (09,48)	NILL	SCT015	+	-
18	19-Dec-18	00,15 (00,05)	NILL	KN016	+	+ (00,20)
19	12-Jan-19	07,30	+TSRA	FEW011CB BKN011	+	+
20	14-Jan-19	10,18	+TSRA	SCT013CB BKN014	+	+
21	15-Jan-19	16,00	+TSRA	SCT005CB BKN013	+	+
22	5-Jan-19	01,26 (01,26)	NILL	SCT016	+	-
23	5-Jan-19	04,10 (04,10)	NILL	SCT017	+	-
24	6-Jan-19	12,15 (12,00)	NILL	FEW017	+	-
25	4-Feb-19	08,44	GUSTY dan - TSRA	FEW015CB BKN017	+	+
26	8-Feb-19	01,30	+TSRA	FEW15CB BKN015	+	+
27	12-Mar-19	07,11	GUSTY dan +TSRA	FEW015CB BKN016	+	radar off
28	21-Mar-19	17,37	+TSRA	BKN013 FEW015CB	+	radar off
29	4-Apr-19	14,35 (14,30)	RA	BKN015	+	+ (14,40)
30	4-May-19	11,30 (11,10)	NILL	SCT015	+	-
31	15-May-19	07,45 (07,30)	NILL	FEW017	+	-

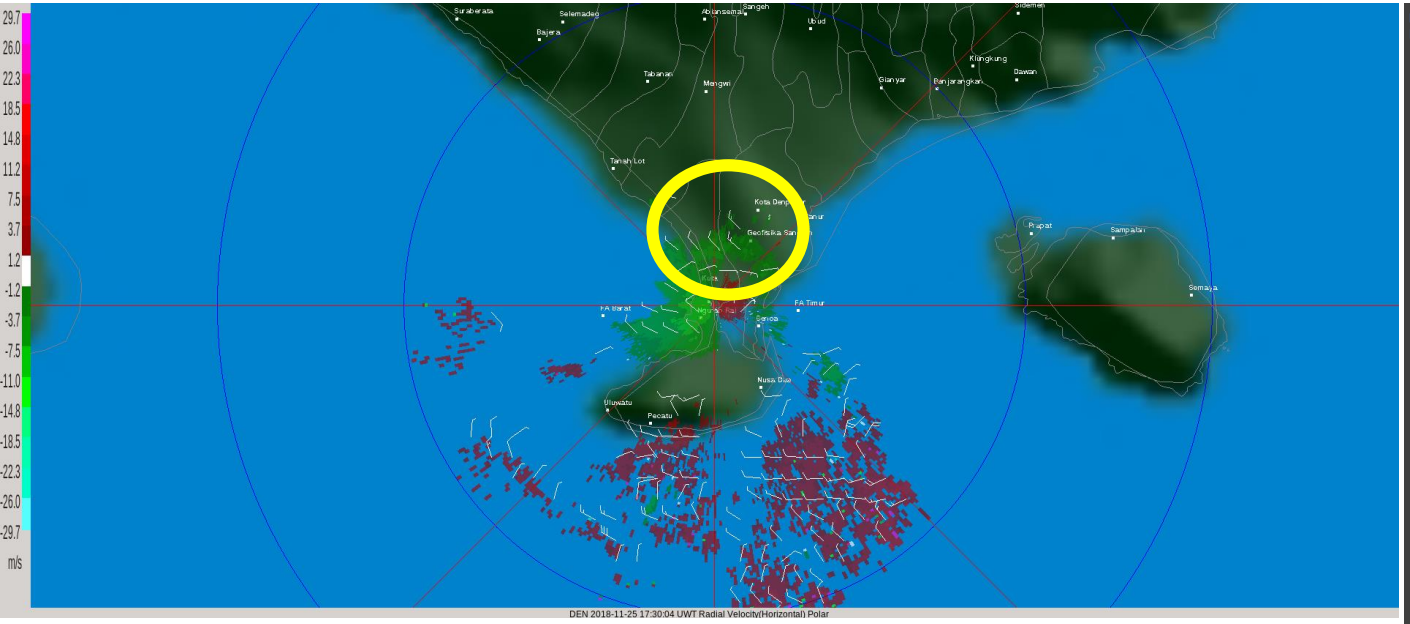
18 Nov 2018 at 11 UTC

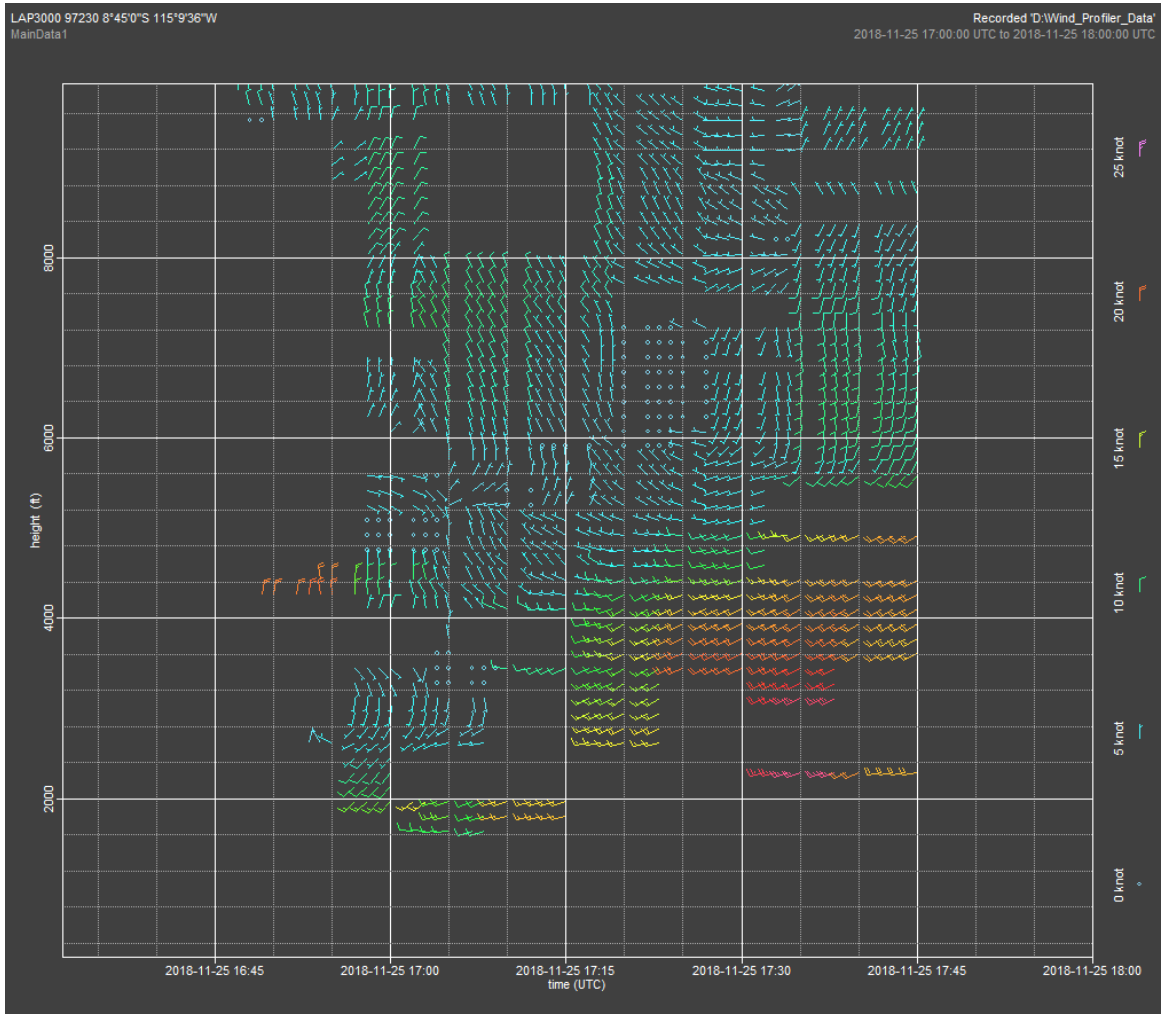




- FEW 1700 FT
- NILL
- RADAR (-)
- WIND PROFILER (+)

25 Nov 2018 at 17.19 UTC





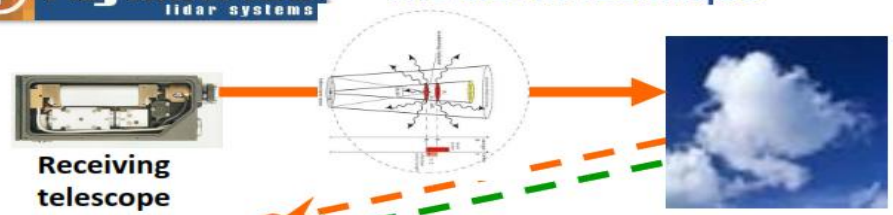
- FEW CB 1400 FT BKN 1500 FT
- RA
- RADAR (+)
- WIND PROFILER (+)

LIDAR Model LR111-ESS-D200

BMKG

raymetrics lidar systems

The LIDAR Technique



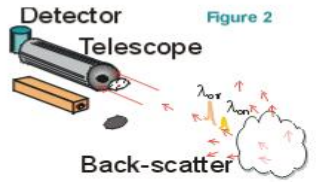
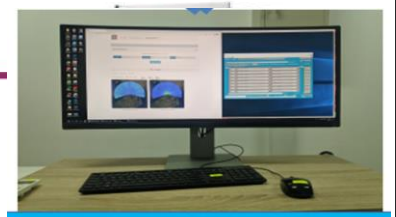
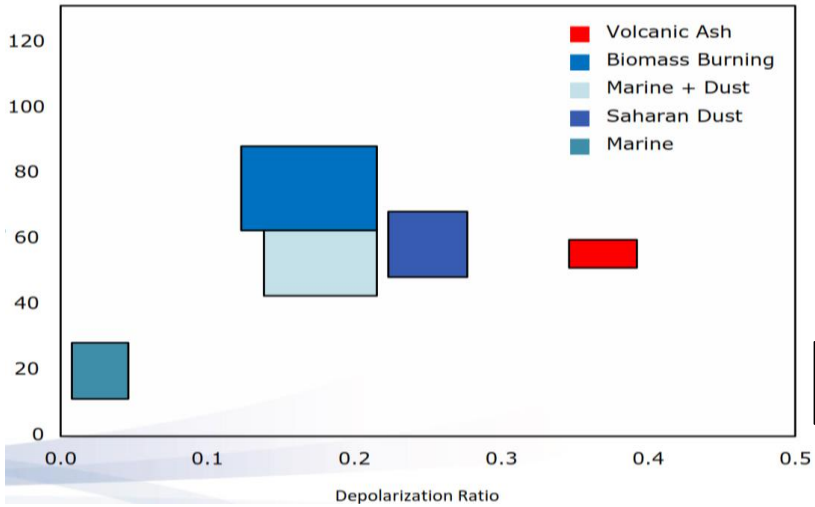


Figure 2

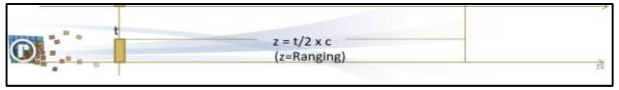


KOMP CLIENT DI OBSERVASI



	Backscatter LIDAR
Clouds	✓
Dust layers	✓
PBL	✓
Backscatter coefficient	✓
Extinction coefficient	○
Optical Depth	○

○: under certain conditions



Principle : Laser Beam from LIDAR reflected by the atmosphere --> received by the telescope --> depolarization analysis for each particles --> VA particles has highest value of depolarization

LIDAR Model LR111-ESS-D200

ADVANTAGES

- Scanning direction, location and time could be set according to needs and conditions
- Could analyze other atmospheric parameters such as Planetary Boundary Layer, strong turbulent motions, classification of cloud types or detection of water / ice content in clouds

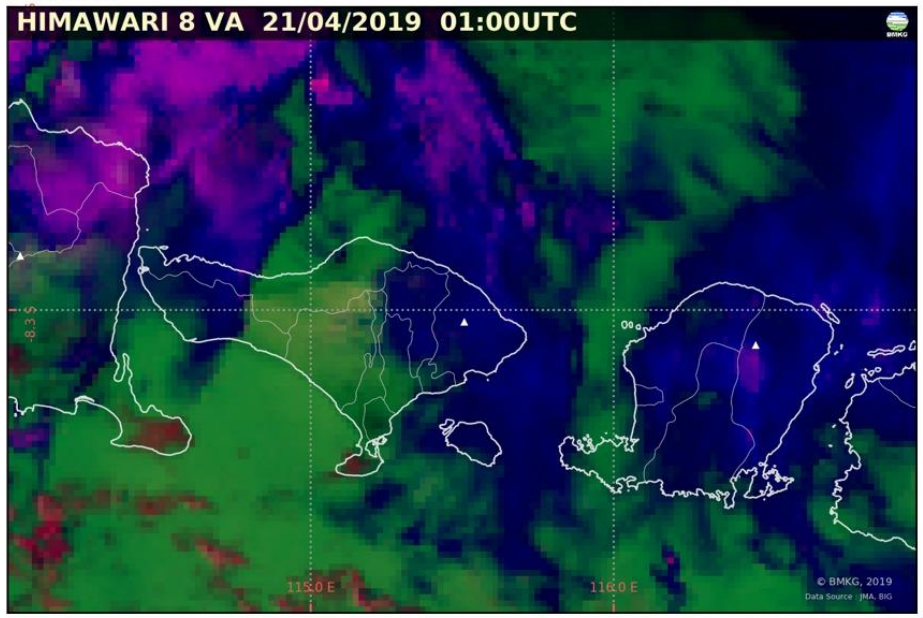
DISADVANTAGES

- Maximum coverage area only can reach radius of 8000 meters;
- Could only operate in good weather condition
- Many low clouds will interfere particles detection in the atmosphere

VOLCANIC ASH EVENT

BMKG

RGB Citra Satelit Cuaca Himawari
Gn. Agung – Tgl 21 April 2019 Pukul 08.00 WIB



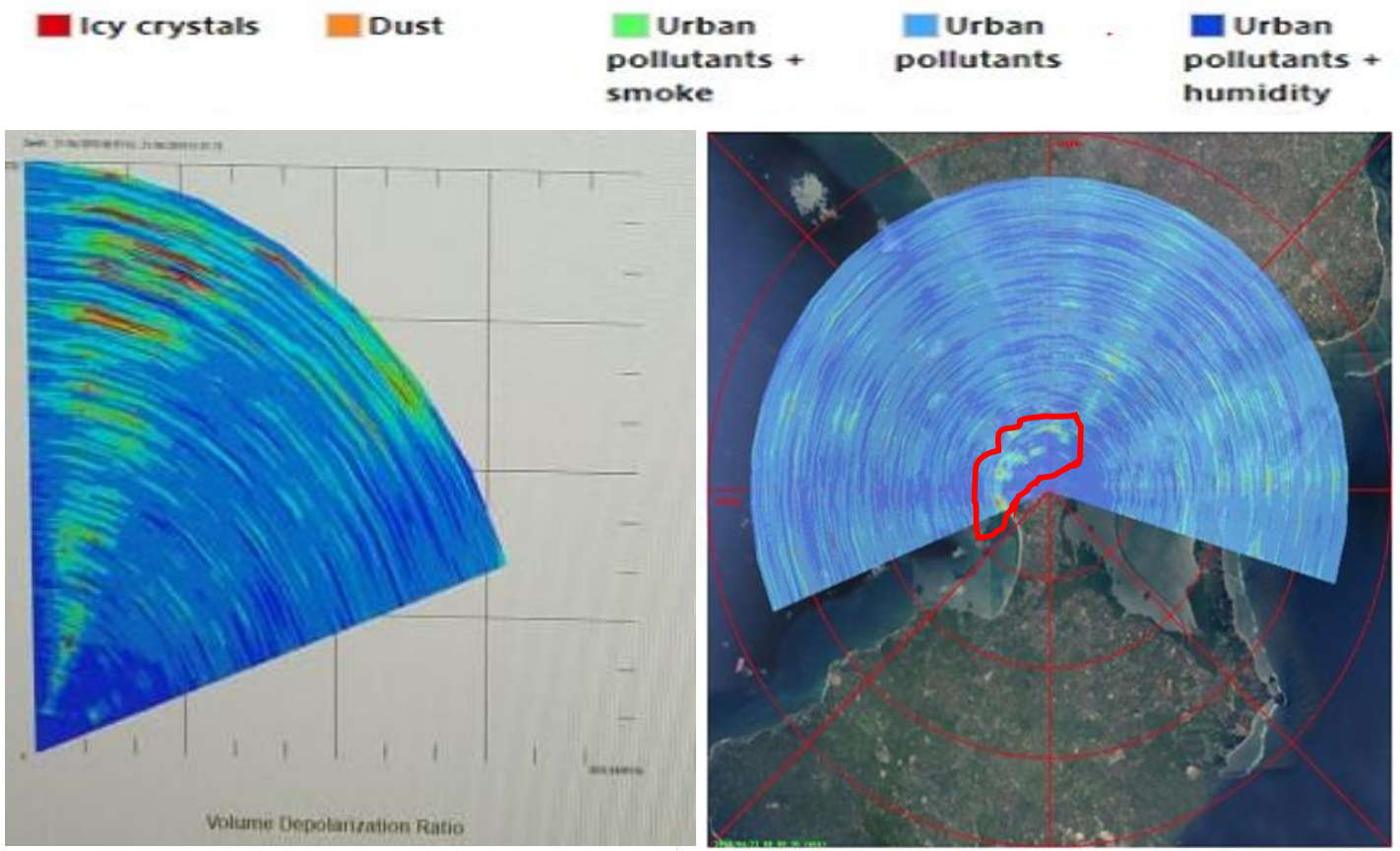
Debu vulkanik tidak terdeteksi. Wilayah Gunung Agung tertutup awan.

SIGMET

```
WVID21 WAAA 202335
WAAZ SIGMET 13 VALID 202335/210535 WAAA-
WAAZ UJUNG PANDANG FIR VA ERUPTION MT AGUNG PSN
S0821 E11530 VA CLD OBS AT 2335Z WI S0848 E11537
- S0858 E11552 - S0905 E11542 - S0901 E11531 -
S0853 E11527 - S0848 E11537 SFC/FL180 MOV S 5KT
NC=
```

Mount Agung Eruption 21 April 2019

Thin Volcanic Ash is detected by LIDAR



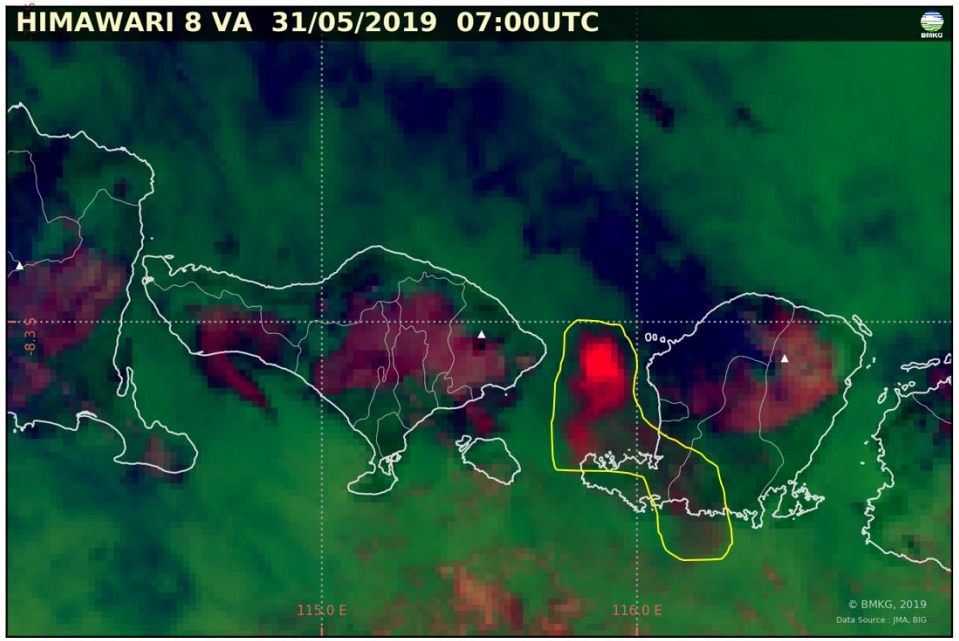
RHI

PPI

VOLCANIC ASH EVENT

BMKG

RGB Citra Satelit Cuaca Himawari
Gn. Agung – Tgl 31 Mei 2019 Pukul 14.00 WIB



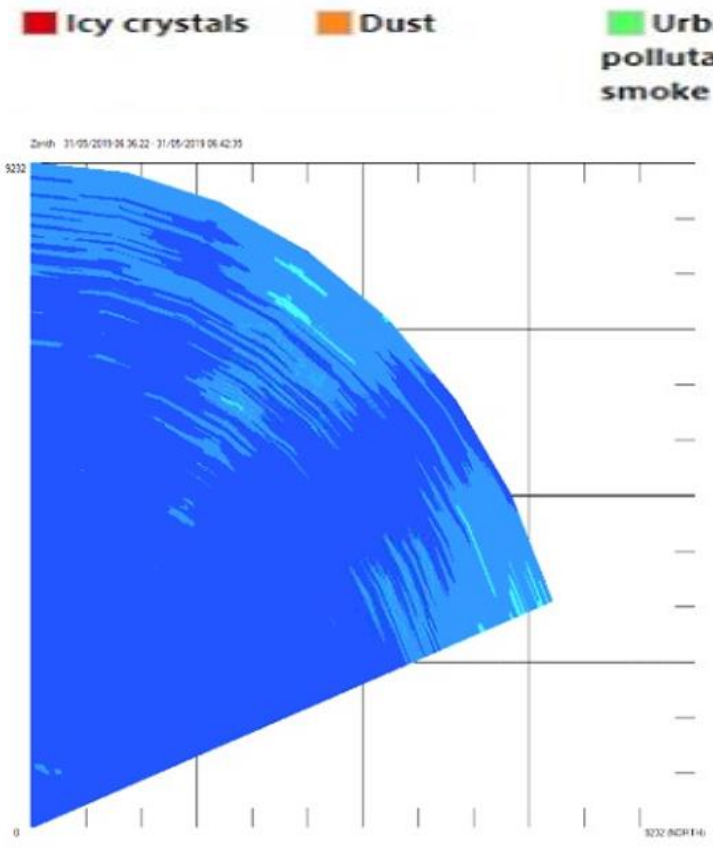
Debu vulkanik terdeteksi bergerak ke arah **Timur** dan **Tenggara**.

SIGMET

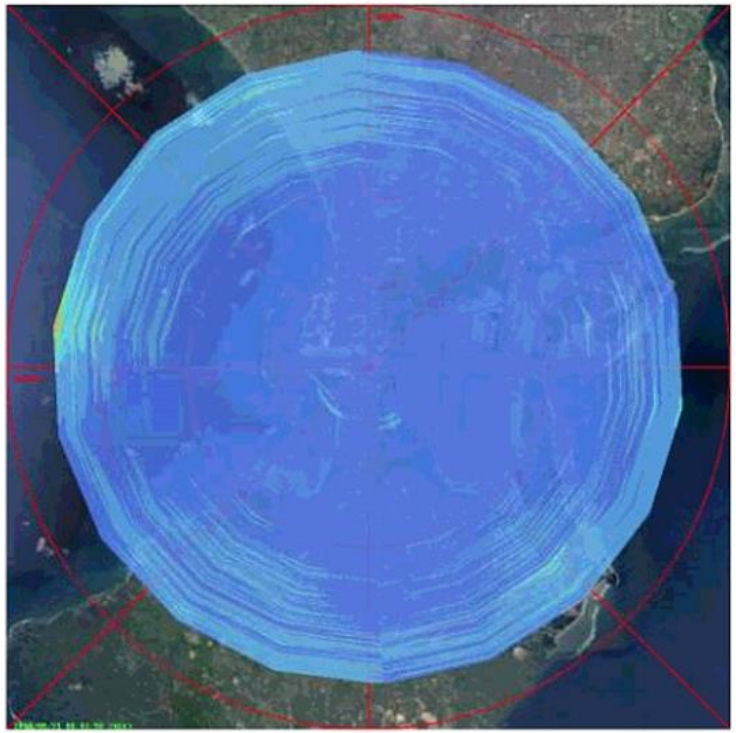
WVID21 WAAA 310720
WAAZ SIGMET 12 VALID 310720/311320 WAAA-
WAAZ UJUNG PANDANG FIR VA ERUPTION MT AGUNG PSN S0821 E11530 VA CLD OBS AT 0720Z WI S0838 E11540 - S0830 E11558 - S0858 E11624 - S0908 E11609 - S0838 E11540 SFC/FL200 VA CLD OBS AT 0720Z WI S0816 E11548 - S0837 E11544 - S0844 E11558 - S0819 E11603 - S0816 E11548 SFC/FL270 FCT AT 1320Z WI S0851 E11619 - S0934 E11637 - S0928 E11659 - S0846 E11644 - S0851 E11619 SFC/FL200 FCT AT 1320Z WI S0822 E11628 - S0827 E11642 - S0850 E11639 - S0846 E11624 - S0822 E11628 SFC/FL270=

Mount Agung Eruption 31 May 2019

Volcanic Ash outside LIDAR Scanning Area

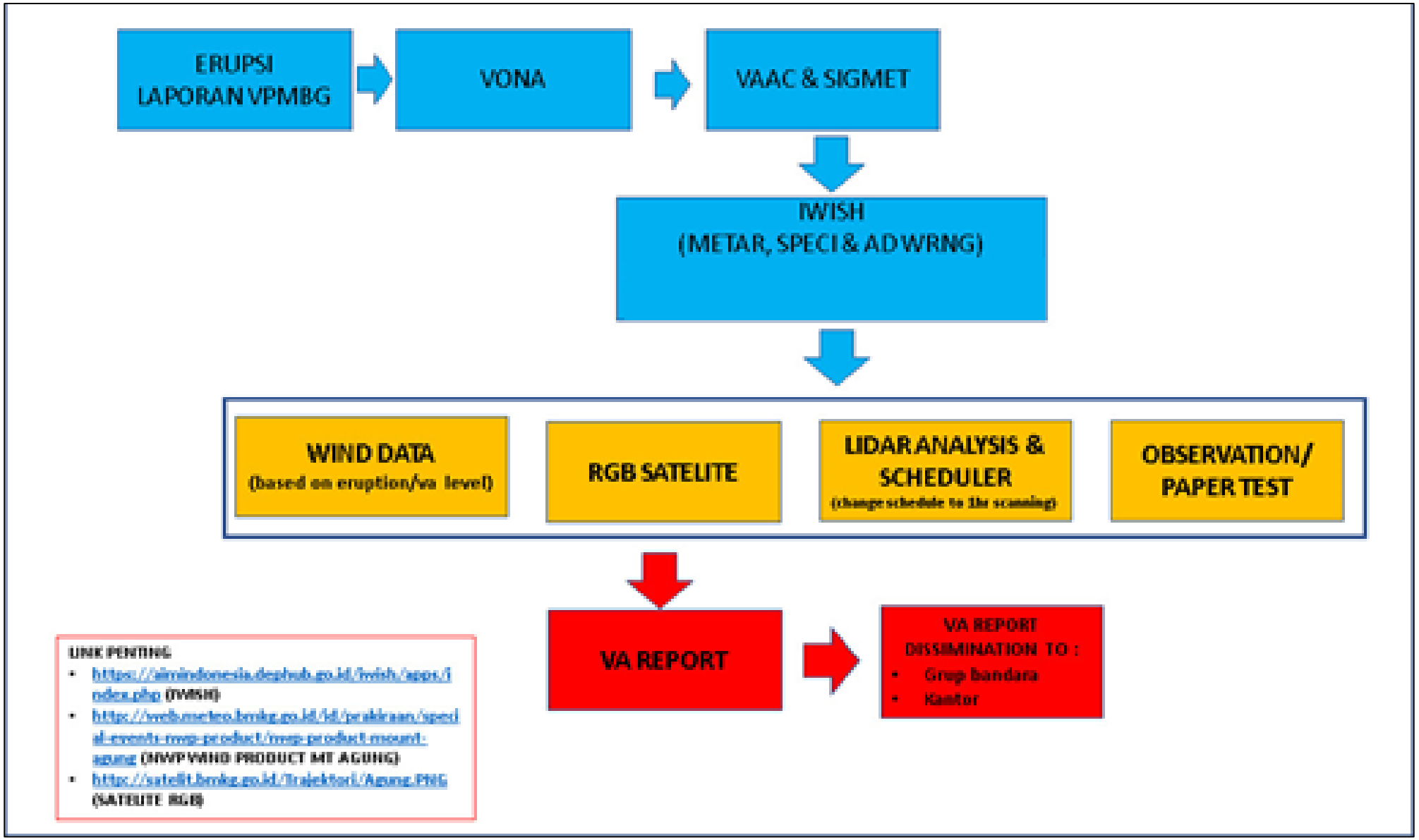


RHI



PPI

FLOW CHART OF VOLCANIC ASH EVENTS REPORTING



CONCLUTION

- *Climate change has significant effects on the aviation*
- *Climate change could cause potential risks to : Physical, Business, Security and environmental sector*
- *Meteorological information is able to mitigate the impact of Climate Change on aviation*
- *The combination of Wind Profiler with Doppler weather RADAR could be utilized to detect turbulence, wind shear, and cross wind due to the Climate Change influence*
- *LIDAR can help mitigate Volcanic Ash events*

THANK YOU

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