Current state of prediction for weather hazards (dust, MCSs and tropical cyclones) in West Africa and Cape Verde

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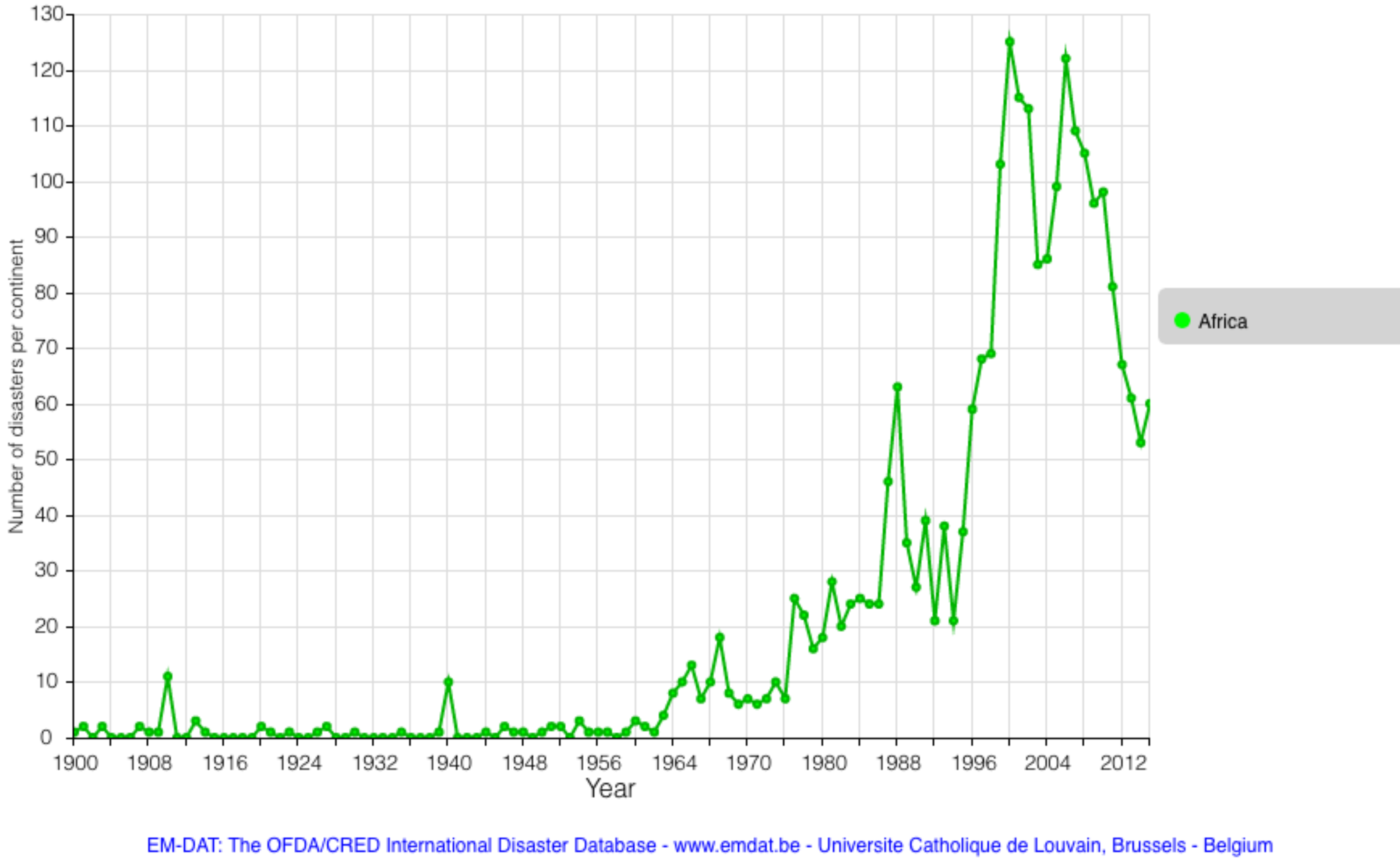
Natural Hazards in Africa

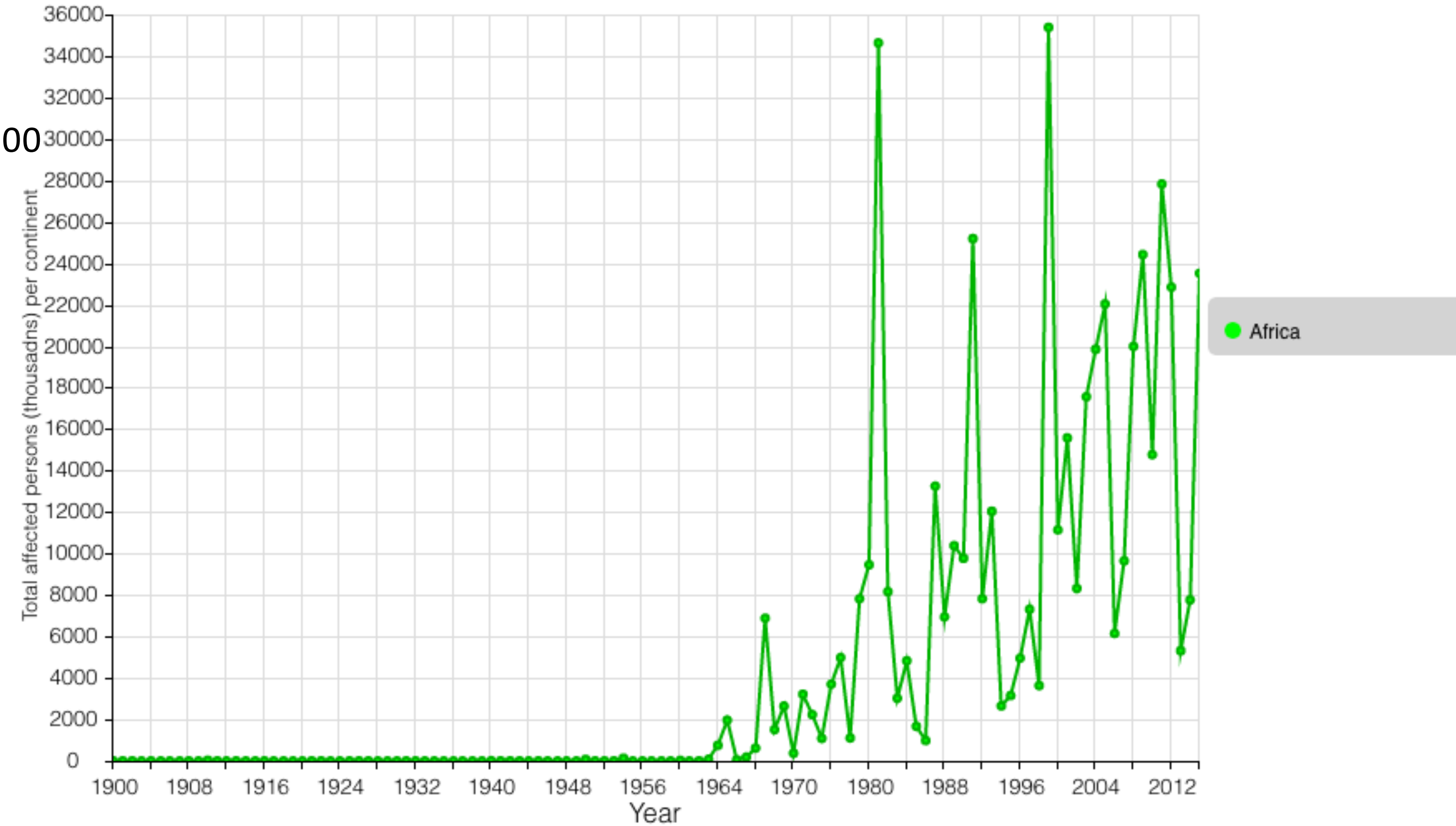
- Floods, droughts, heat waves, dry spells… have increased their impacts over the last few decades.
- Causes
  - Weak infrastructure
  - Increased population
  - Vulnerable populations
  - Limited forecasting capabilities
  - Climate variability
  - Anthopogenic climate change

Increase in the number of Natural disasters in Africa



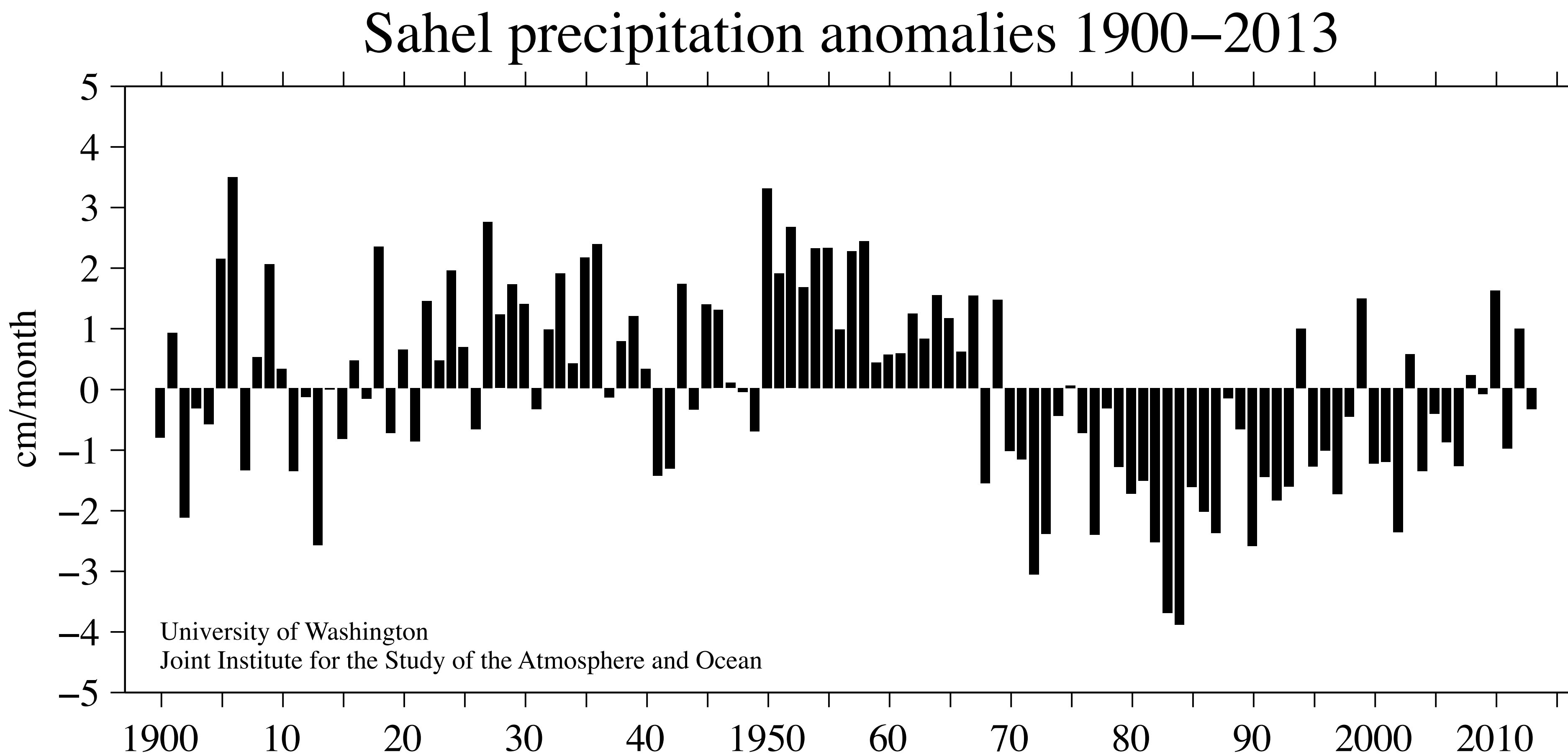
Many more persons are being impacted by natural disaster in Africa since 1970 affected by Natural disasters

30,000,000



EM-DAT: The OFDA/CRED International Disaster Database - www.emdat.be - Universite Catholique de Louvain, Brussels - Belgium

20th century drying may bias the view on hazards while disrupting WA economies.



June through October averages over 20−10N, 20W−10E. 1900−2013 climatology
NOAA NCDC Global Historical Climatology Network data

Evolution of Weather forecasting and tools limited in West Africa

- Over the last 5 decades, significant improvements have occurred in NWP models, observations, tools and applications of both for protection of life and property.
- These improvements have not yet reached West Africa.
- Consequences: Forecasters are handicapped and have limited ability to protect growing and vulnerable populations.

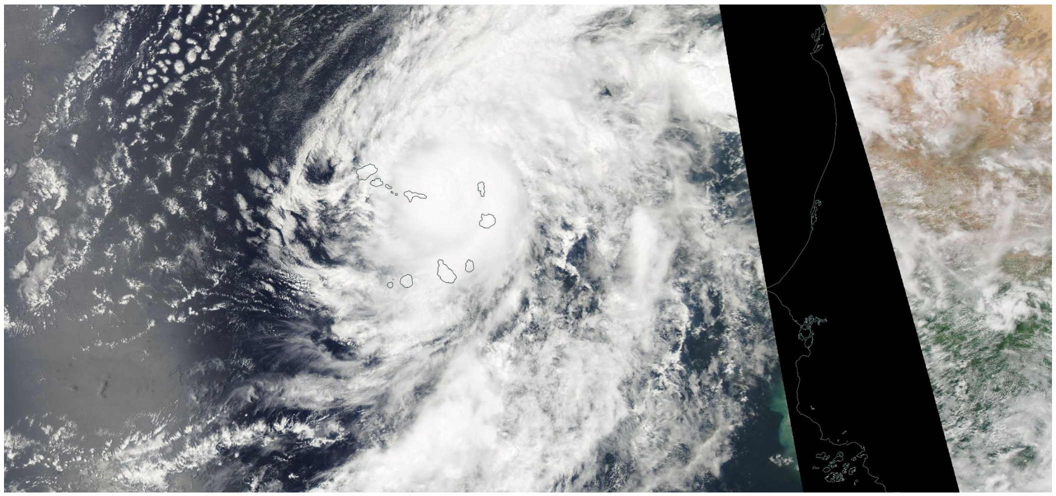
Questions

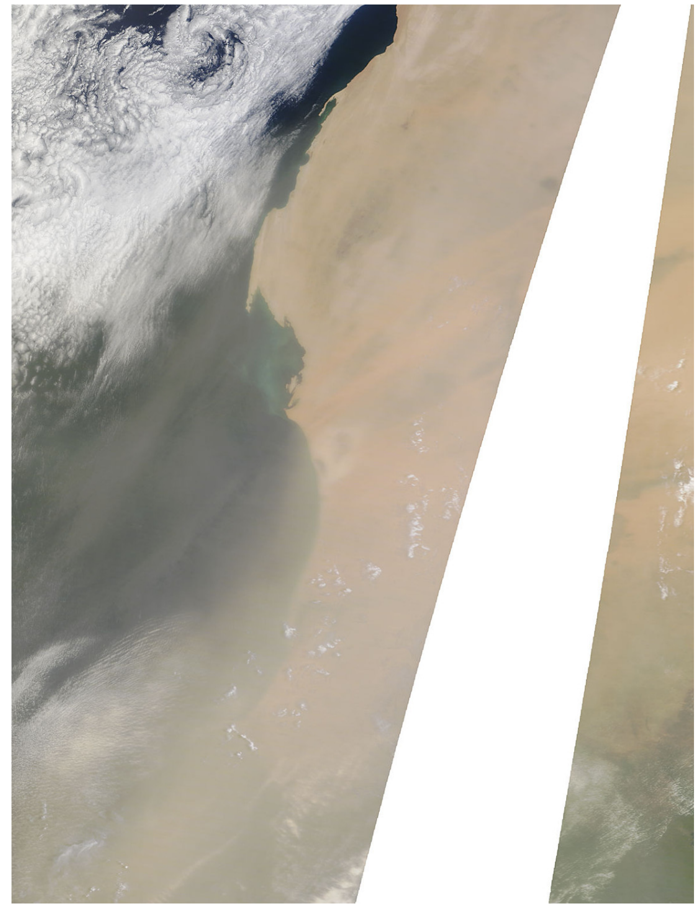
1. Can forecasters provide reliable short-medium range forecasts for hazards affecting the public in West Africa?
2. What are the current limits of prediction for weather hazards in West Africa?
3. What are the some solutions improving short-medium range forecasts in West Africa for Hazards.

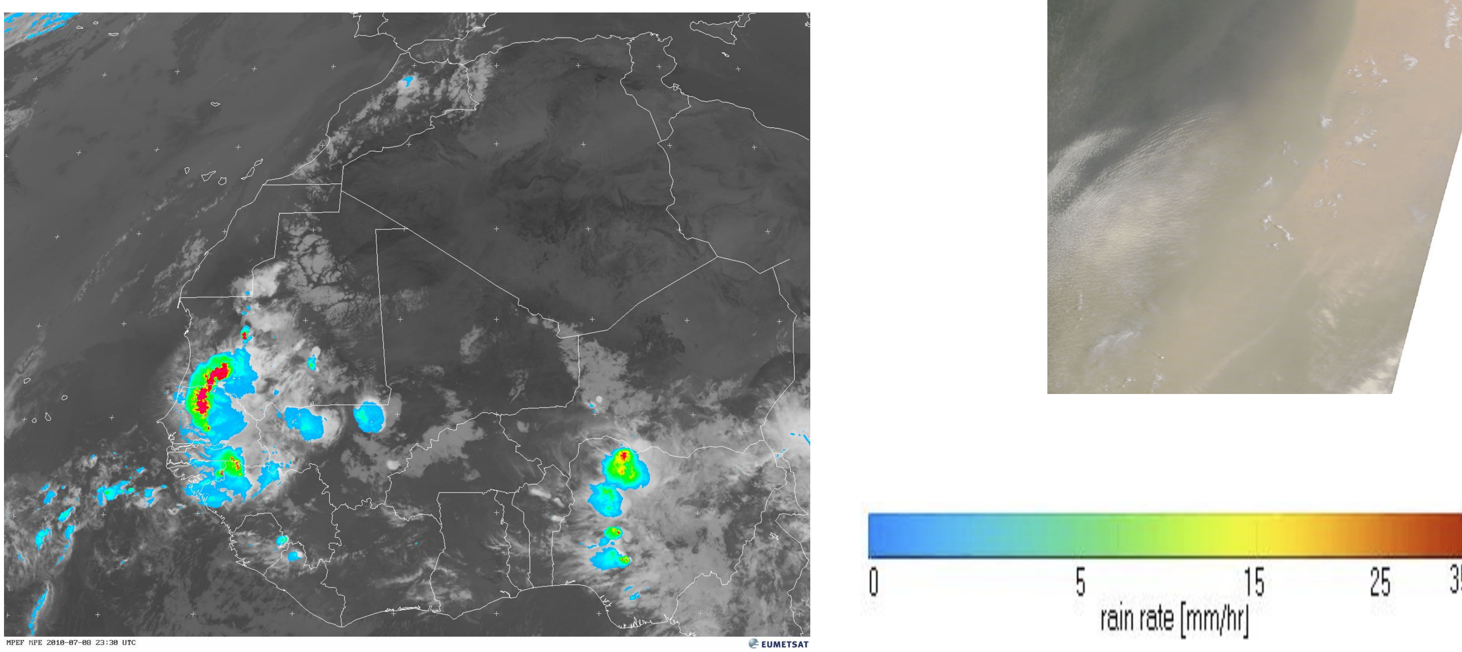
Improving predictability of hazards can serve as an climate change adaptation strategy

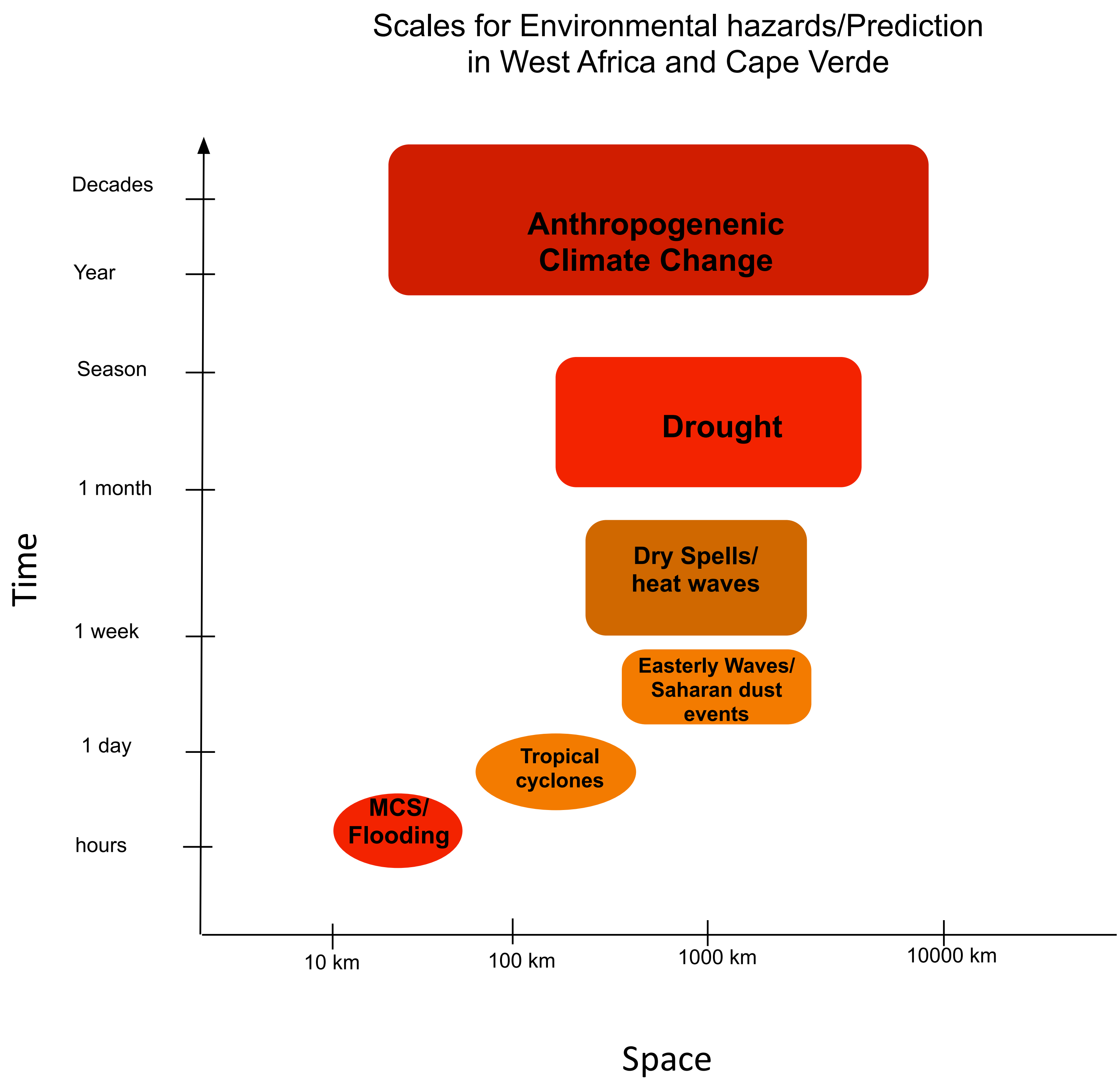
- The potential to lessen impacts on vulnerable population from extreme events.
- Develop synergy with responders.
- Improve communications to stakeholders
- Build capacity to address hazards which may be more intense with anthropogenic climate change.

Natural Hazards in West Africa, Cape Verde








Scales for Environmental hazards/Prediction
in West Africa and Cape Verde
Time
Decades
Year
Season
1 month
1 week
1 day
hours
Anthropogenic Climate Change
Drought
Dry Spells/ heat waves
Easterly Waves/ Saharan dust events
Tropical cyclones
MCS/ Flooding
10 km
100 km
1000 km
10000 km
Space

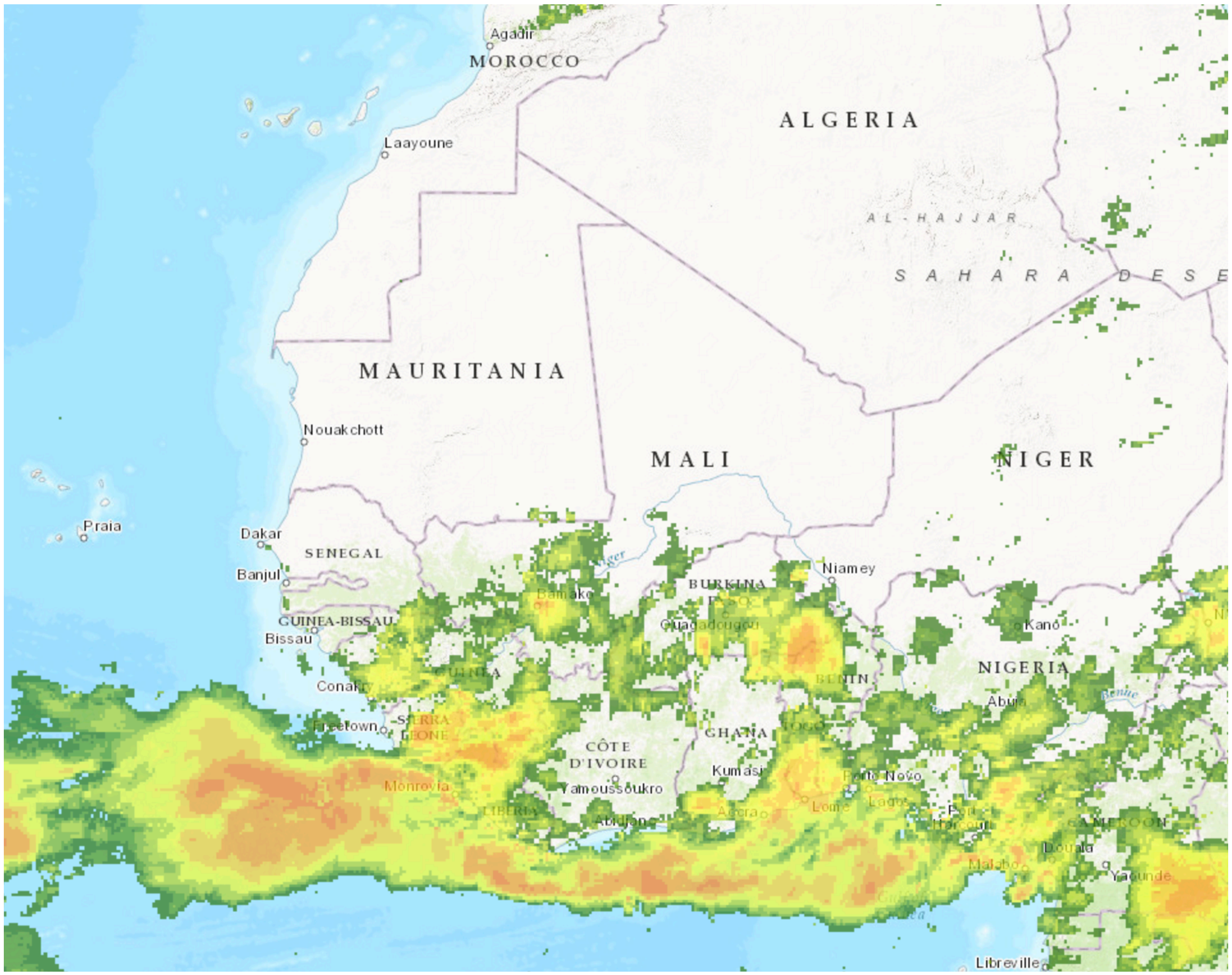
Annual and seasonal hazards

- Annual
- Coastal hazards (rip currents), coastal flooding
- Winter/Spring
  - Air Quality/airport closures
- Summer
  - Air Quality (Caribbean and US), Severe weather, tropical disturbances, flooding

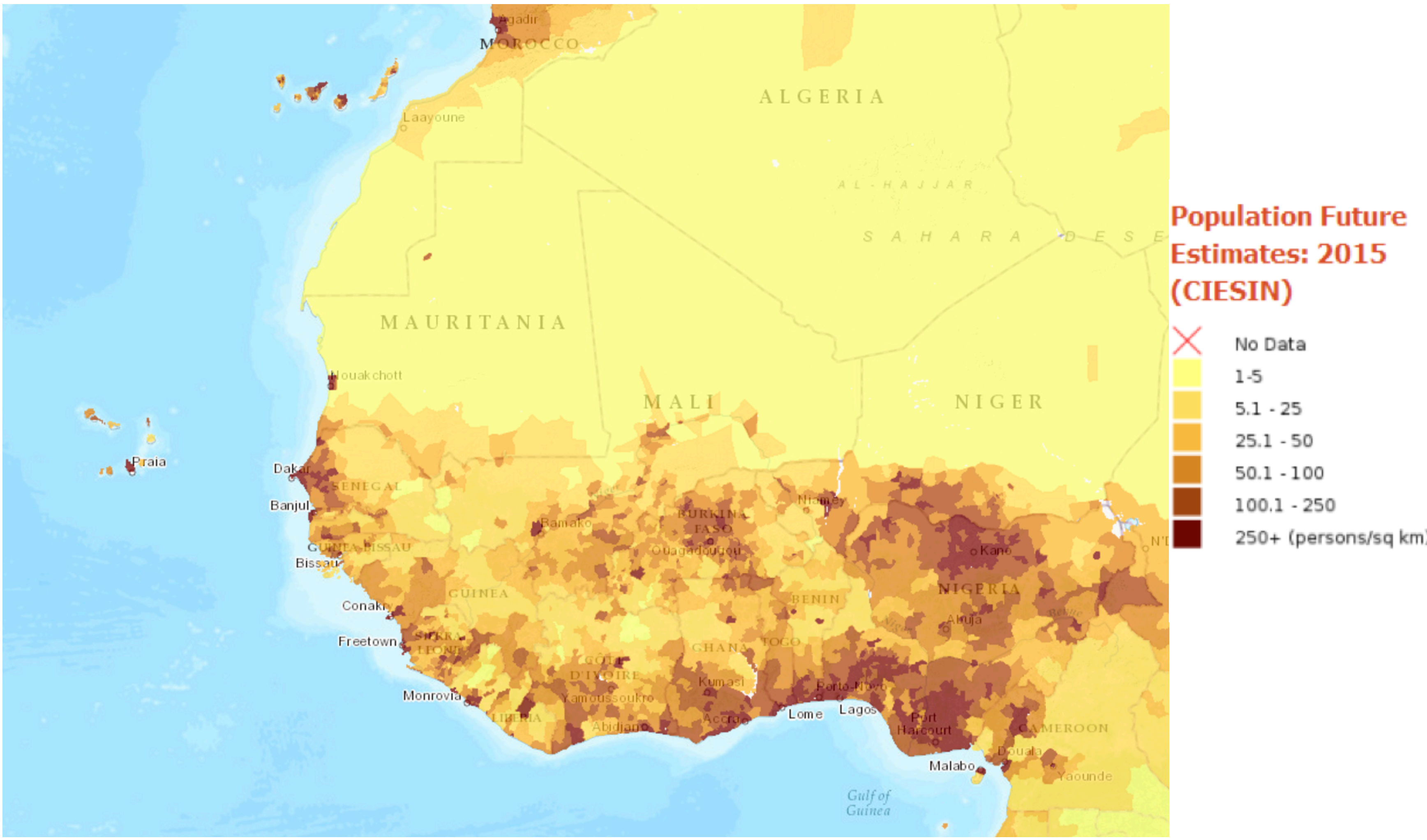
Possibility for successfully predicting these hazards on short to medium range

- Saharan dust events --- Good
- Tropical Disturbances – Average
- MCSs – poor to average

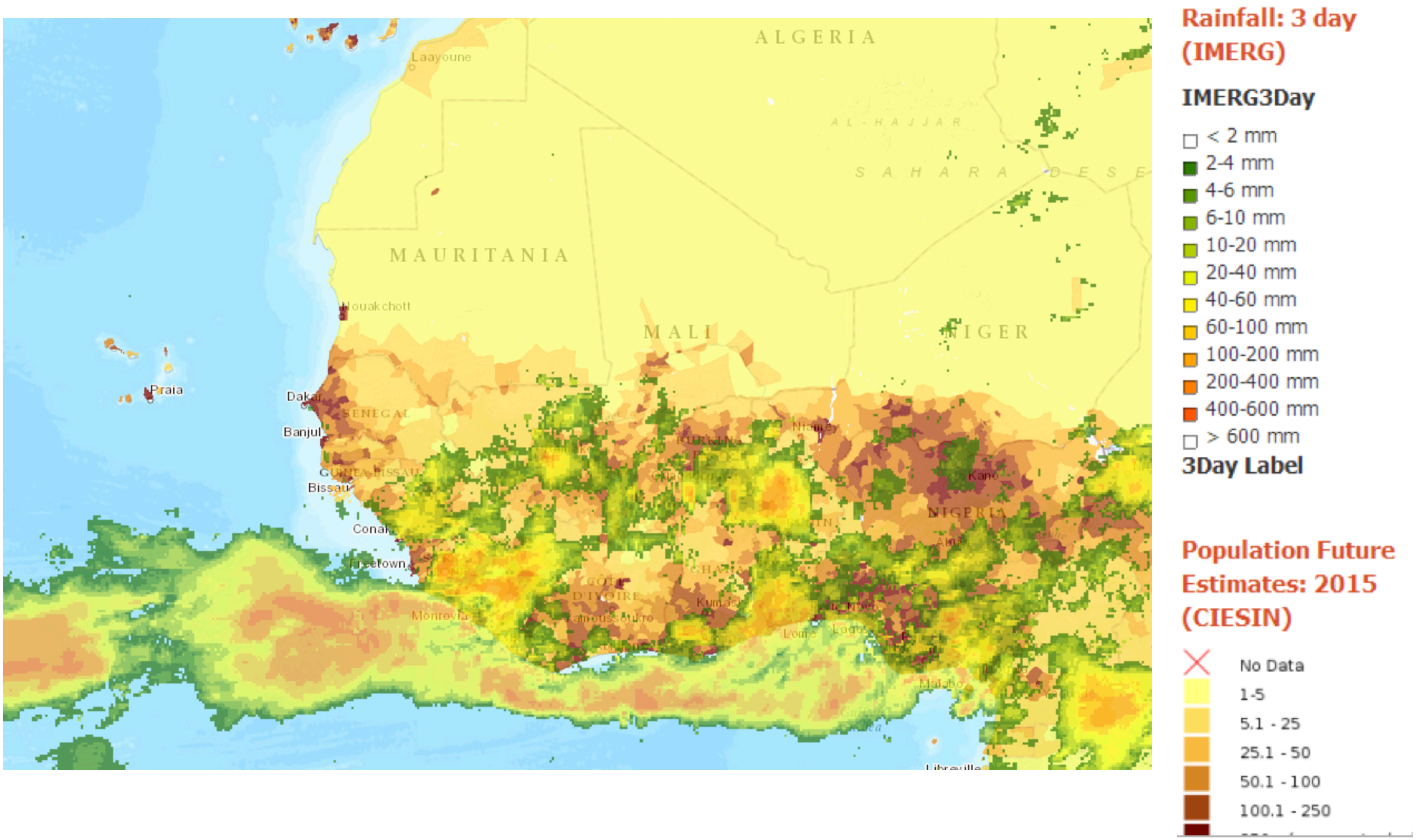
Forecaster mode: GPM IMERGE 3 day rain accumulation



Population Density



Forecaster mindset: Precipitation and population density

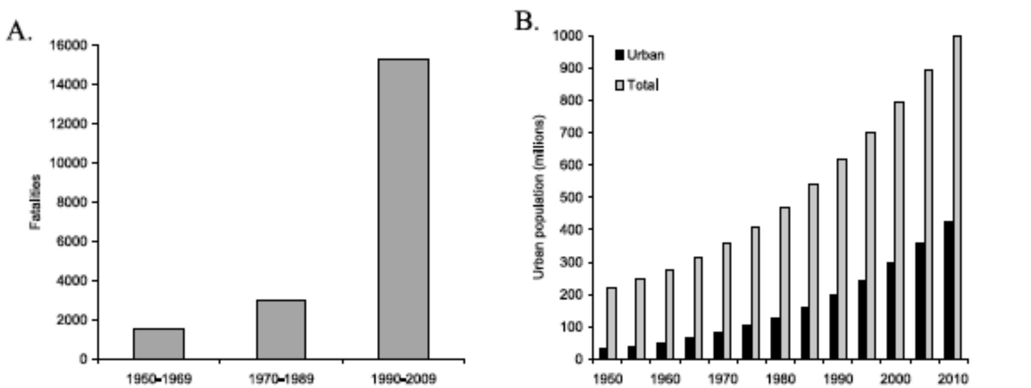


Mesoscale Convective System predictability challenges

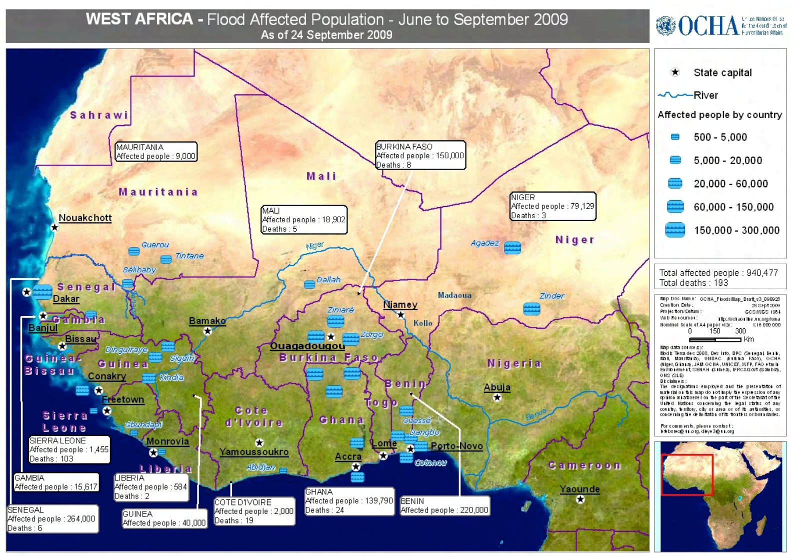
- Goal: 0-24 hour QPF associated with MCSs
- Challenges
  - Limited daily soundings across West Africa for model initialization and assimilation
  - Extremely limited radar data
  - Moisture initialization and convective initiation.
  - High spatial resolution required for simulating physical processes
  - Role of physical processes (e.g. aerosols and microphysics) within MCSs are complex.
  - Systems are long-lived (6 -48 hours)

Mesoscale convective systems- responsible for life-giving rainfall and flooding in West Africa

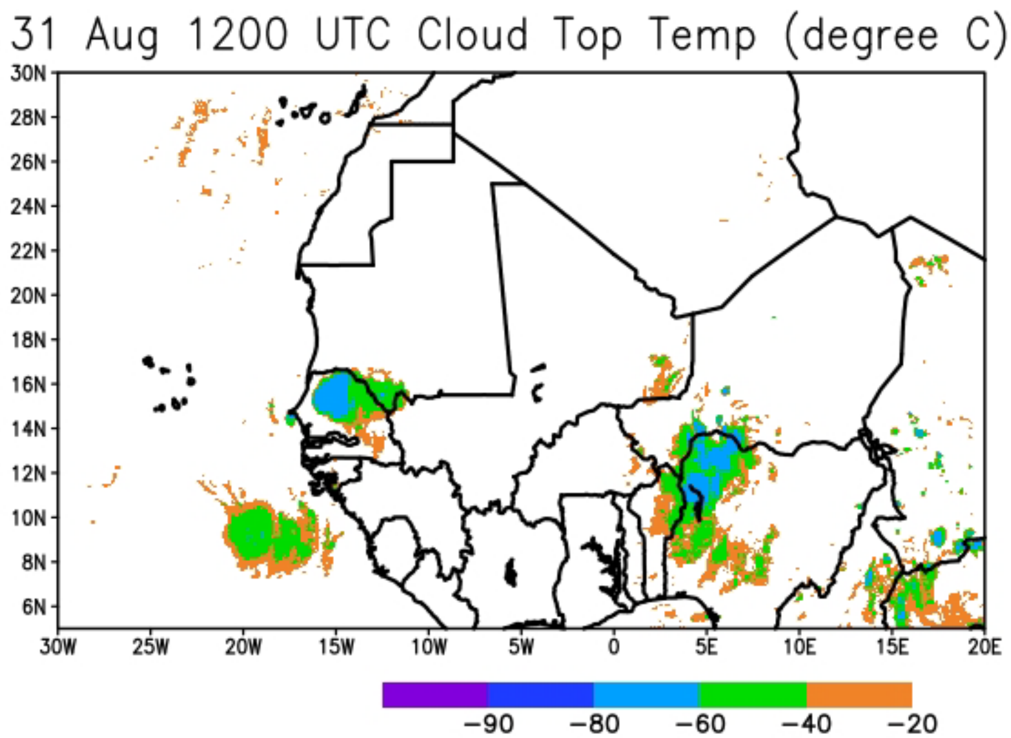
DI BALDASSARRE ET AL.: FLOOD FATALITIES IN AFRICA L2



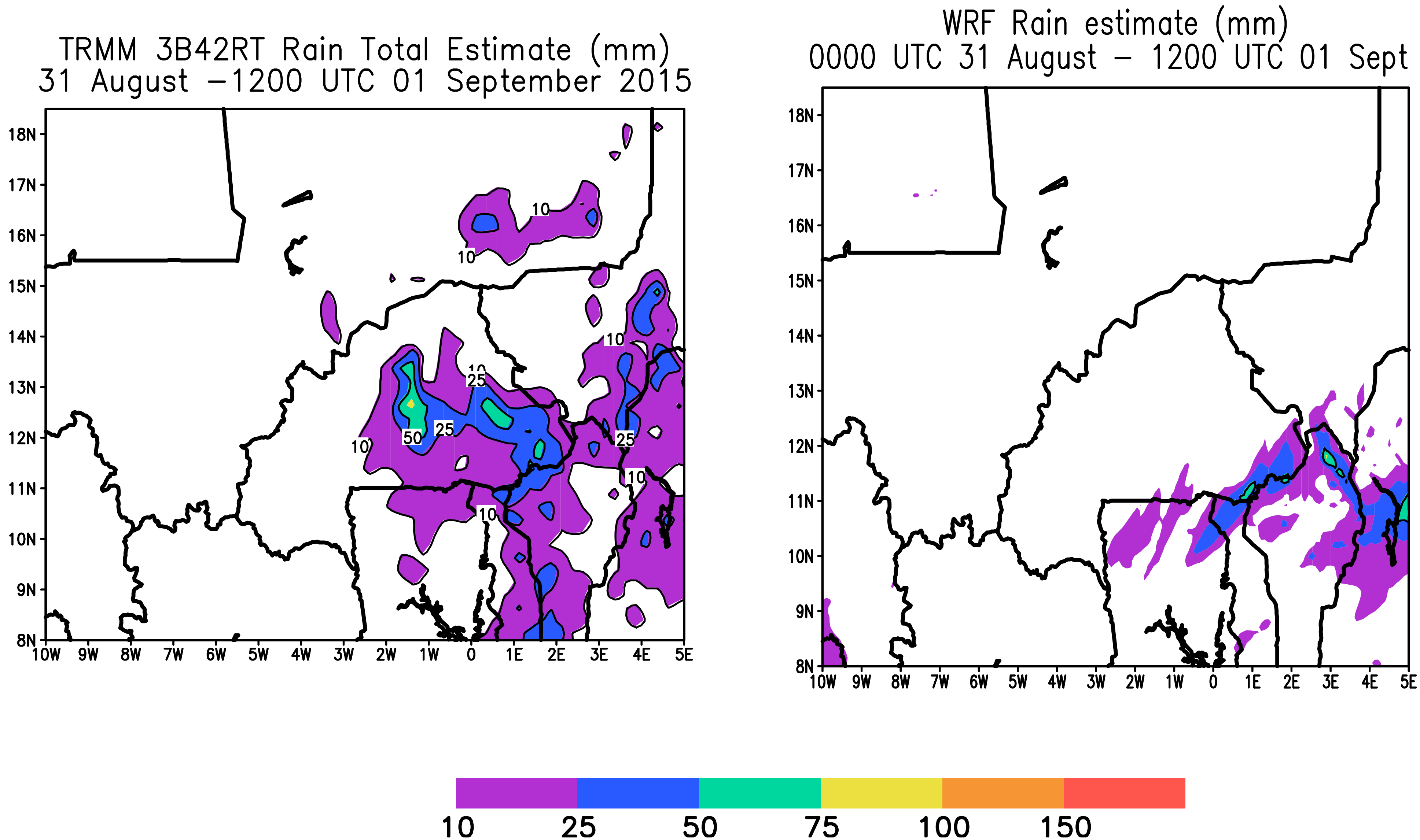
Inventory data for the African continent, 1950–2010. (a) Fatalities caused by floods [*CRED*, 2004]. (b) Total ulation [*United Nations*, 2002].



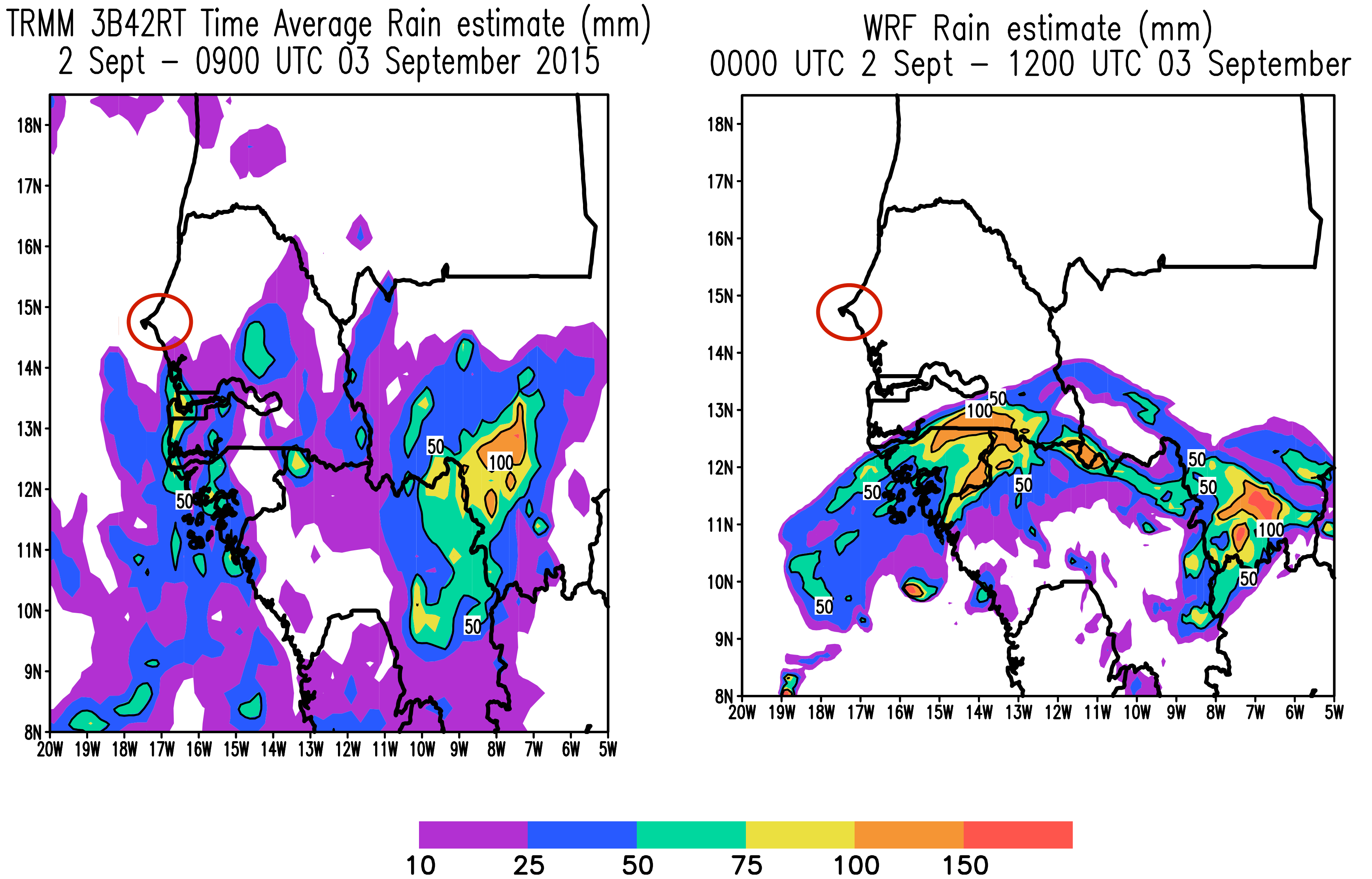
August 31-Sept 2 IR Storm



TRMM/WRF Precipitation estimates of MCS rain 31 August-1 Sept. 2009



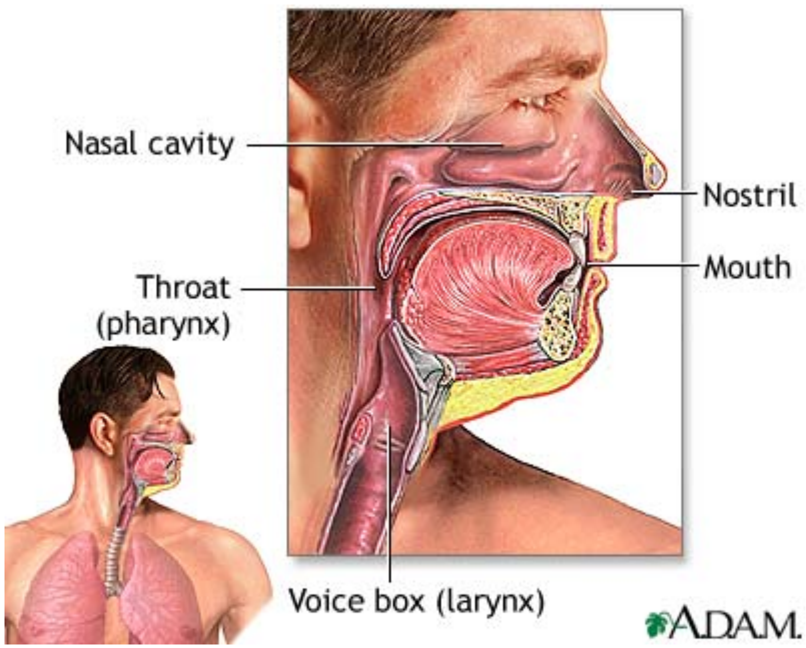
TRMM/WRF Precipitation estimates of MCS rain 2-3 September 2009

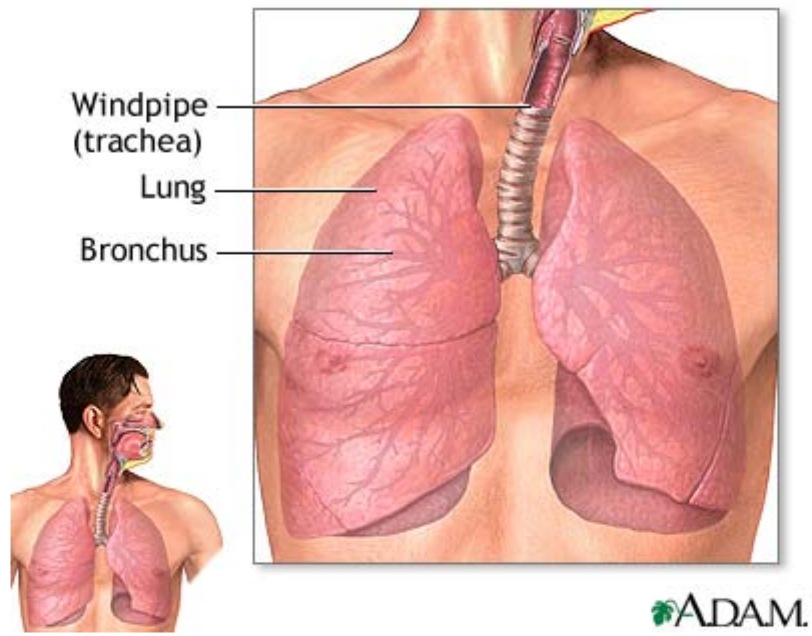


Saharan Dust Storm Prediction challenges

- Goal:
  - Forecast 3-5 days prior to impact
  - Forecast Spatial scales of dust events
  - Forecast Intensity of dust events (PM2.5, PM10) - concentrations
- Understand
  - Impacts on large population centers
  - Impacts and implications on non-communicable disease (asthma, COPD) and communicable disease (Meningitis, TB)

Upper and lower respiratory issues





Asthma, Meningitis,

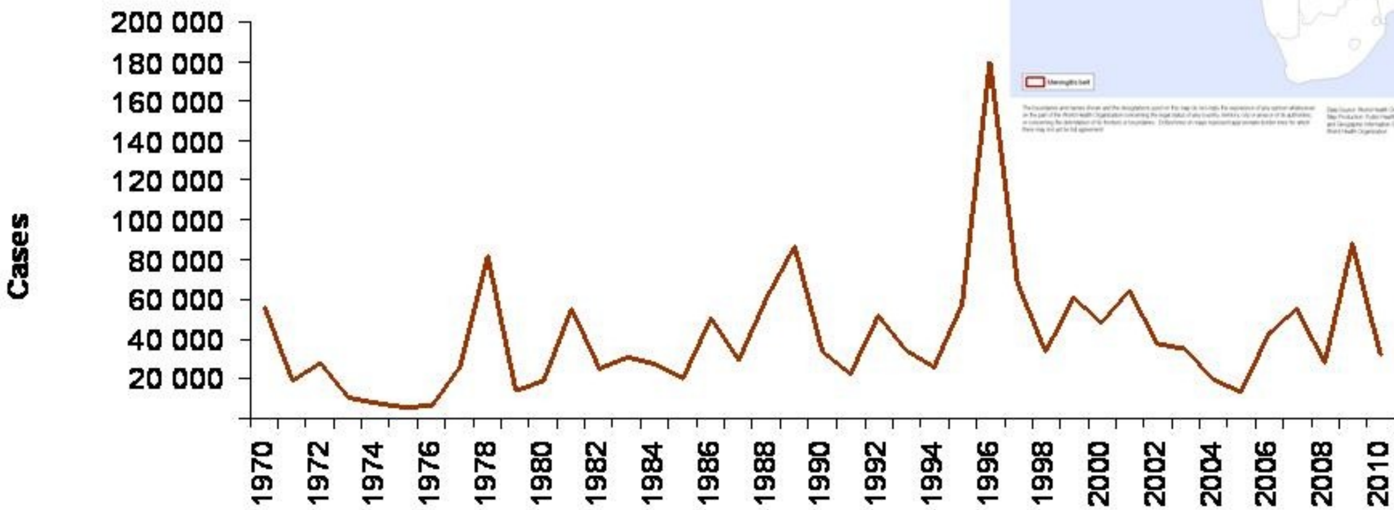
Bronchitis, COPD

PM 10

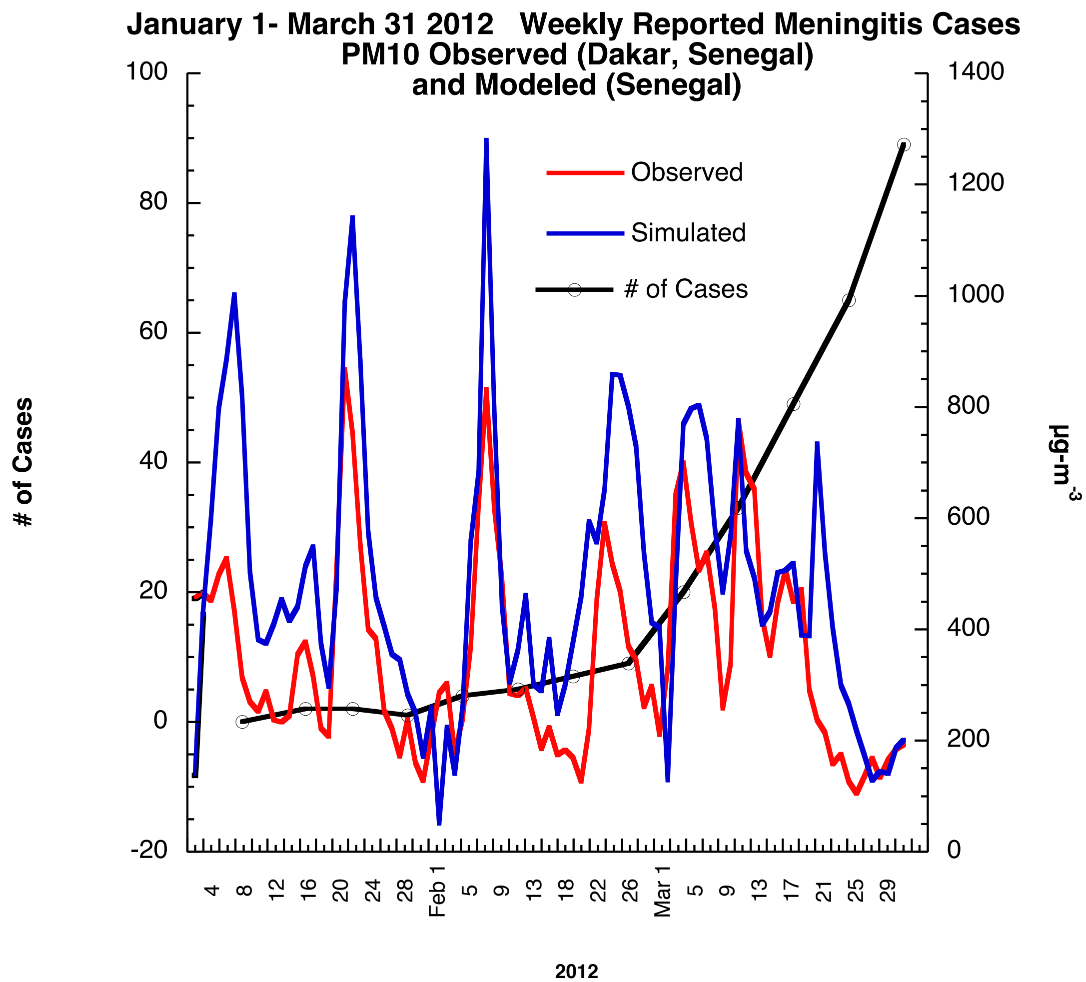
PM 2.5

Epidemics in the Meningitis Belt

Trends of epidemic meningitis disease in the African belt, 1970-2010



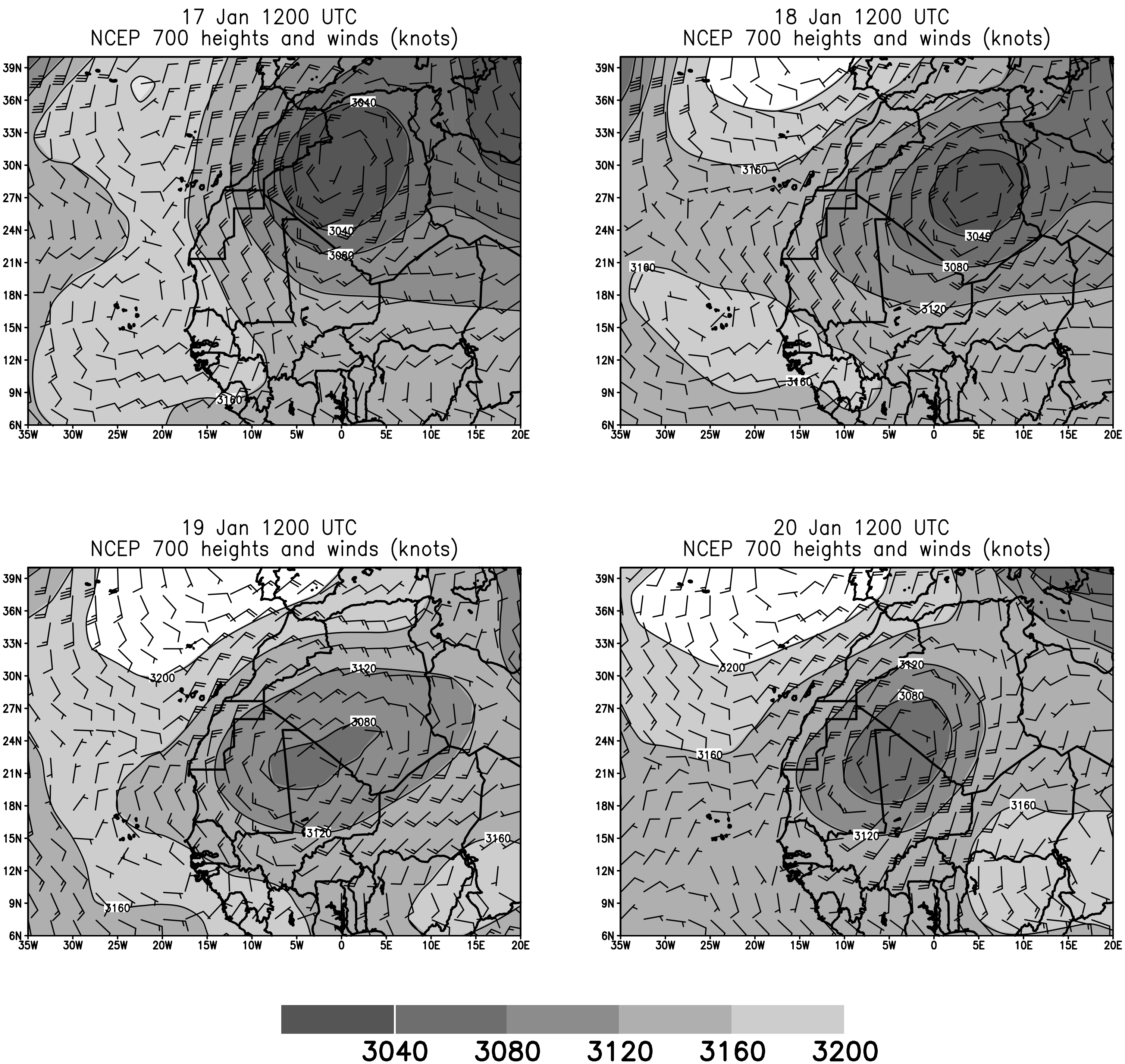
WRF is able to simulate PM 10 for Senegal when compared to Dakar Observations Why?



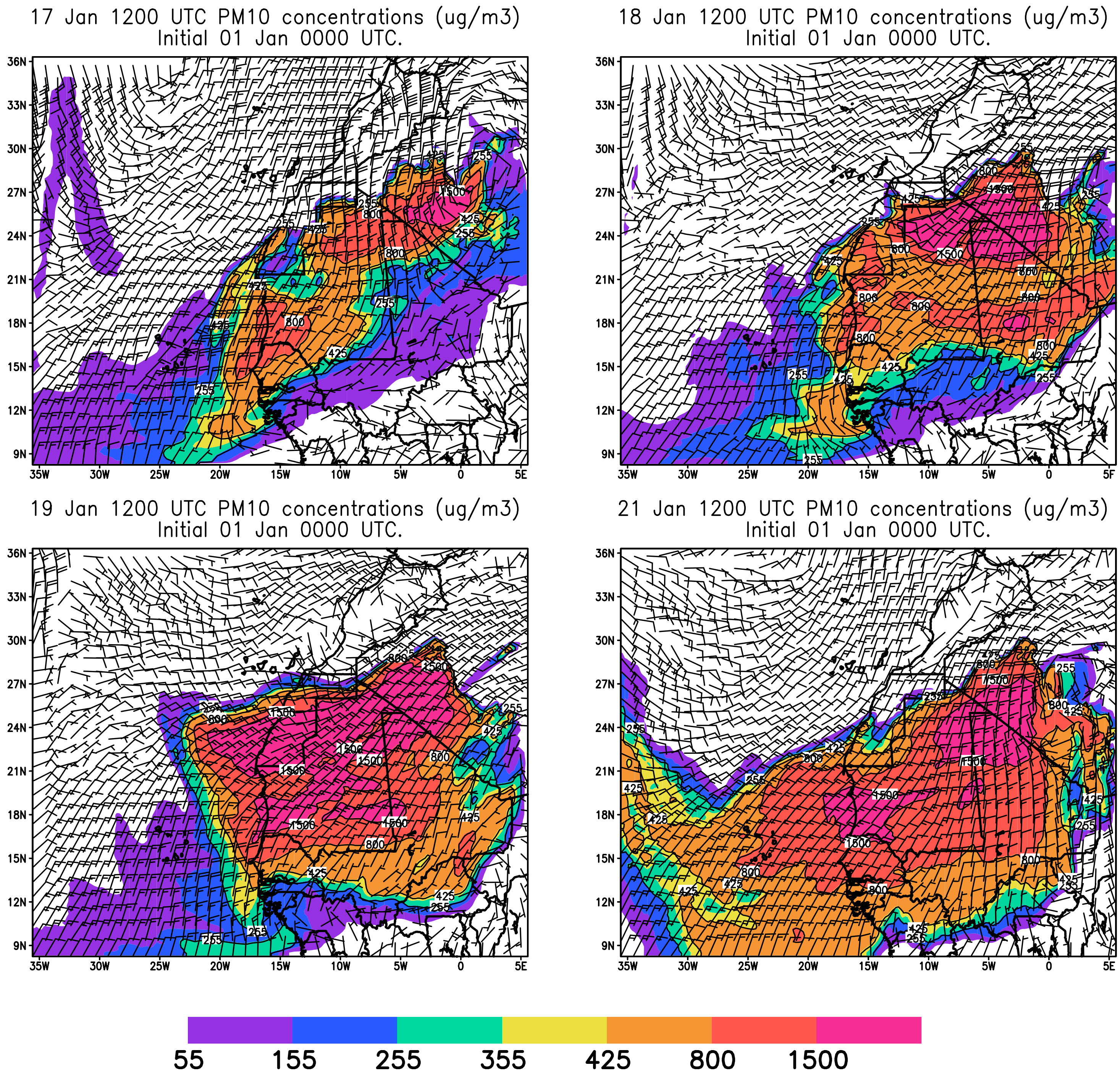
Doikhane et al. 2016

Large-scale circulation drives Saharan dust events (summer and winter)

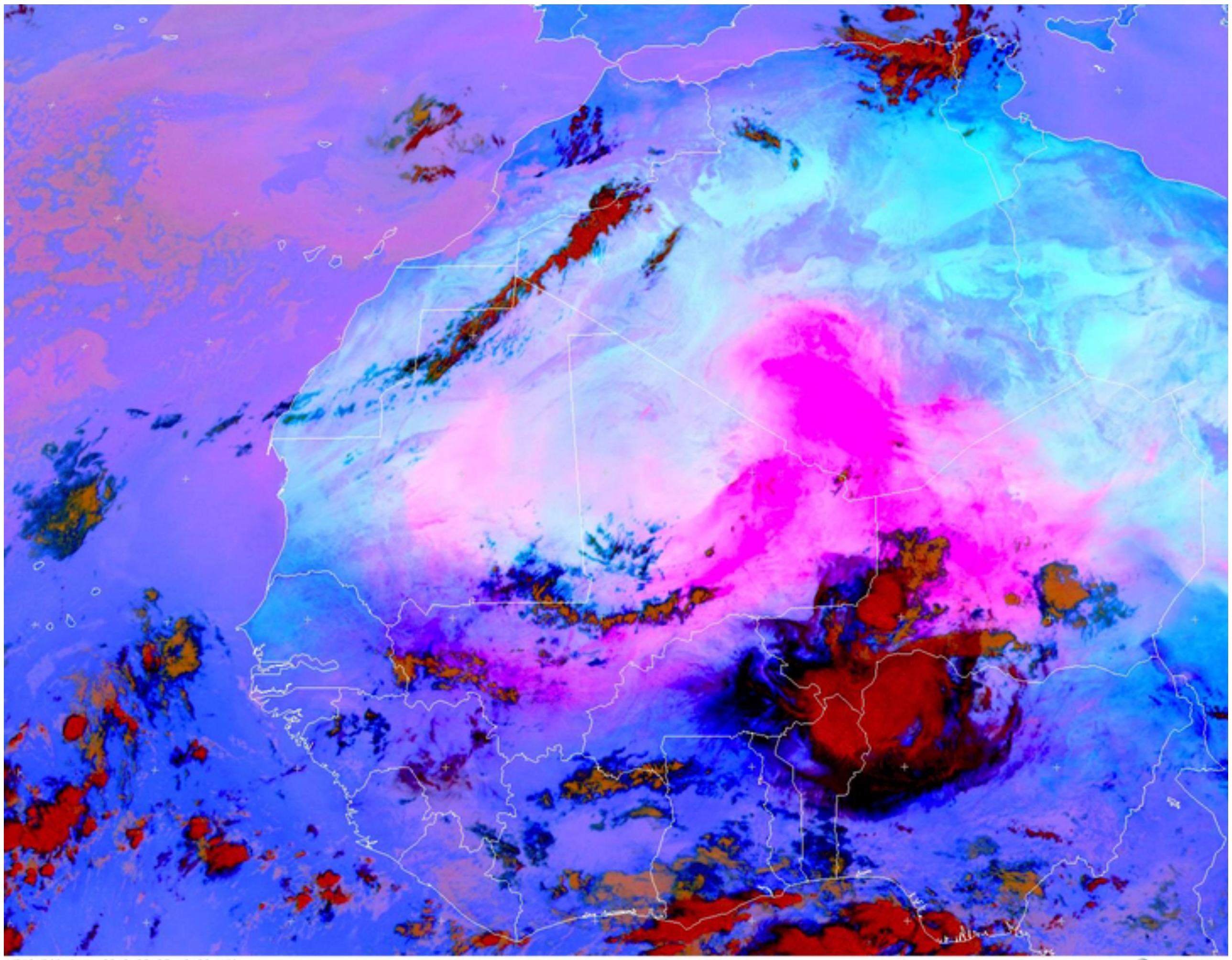
- Sub-tropical troughs/ridges move into North Africa driving winter season events.
- Thermal low/AEWs drive summer dust events.
- Global models do a good job on synoptic scale features
- Consequences:
  - Boundary conditions for regional dust models are more important than initial conditions.



17 Jan 1200 UTC
NCEP 700 heights and winds (knots)
18 Jan 1200 UTC
NCEP 700 heights and winds (knots)
19 Jan 1200 UTC
NCEP 700 heights and winds (knots)
20 Jan 1200 UTC
NCEP 700 heights and winds (knots)
39N 36N 33N 30N 27N 24N 21N 18N 15N 12N 9N 6N
35W 30W 25W 20W 15W 10W 5W 0 5E 10E 15E 20E
3040 3080 3120 3160 3200


17 Jan 1200 UTC PM10 concentrations (ug/m3)
Initial 01 Jan 0000 UTC.
18 Jan 1200 UTC PM10 concentrations (ug/m3)
Initial 01 Jan 0000 UTC.
19 Jan 1200 UTC PM10 concentrations (ug/m3)
Initial 01 Jan 0000 UTC.
21 Jan 1200 UTC PM10 concentrations (ug/m3)
Initial 01 Jan 0000 UTC.
36N
33N
30N
27N
24N
21N
18N
15N
12N
9N
35W
30W
25W
20W
15W
10W
5W
0
5E
55
155
255
355
425
800
1500

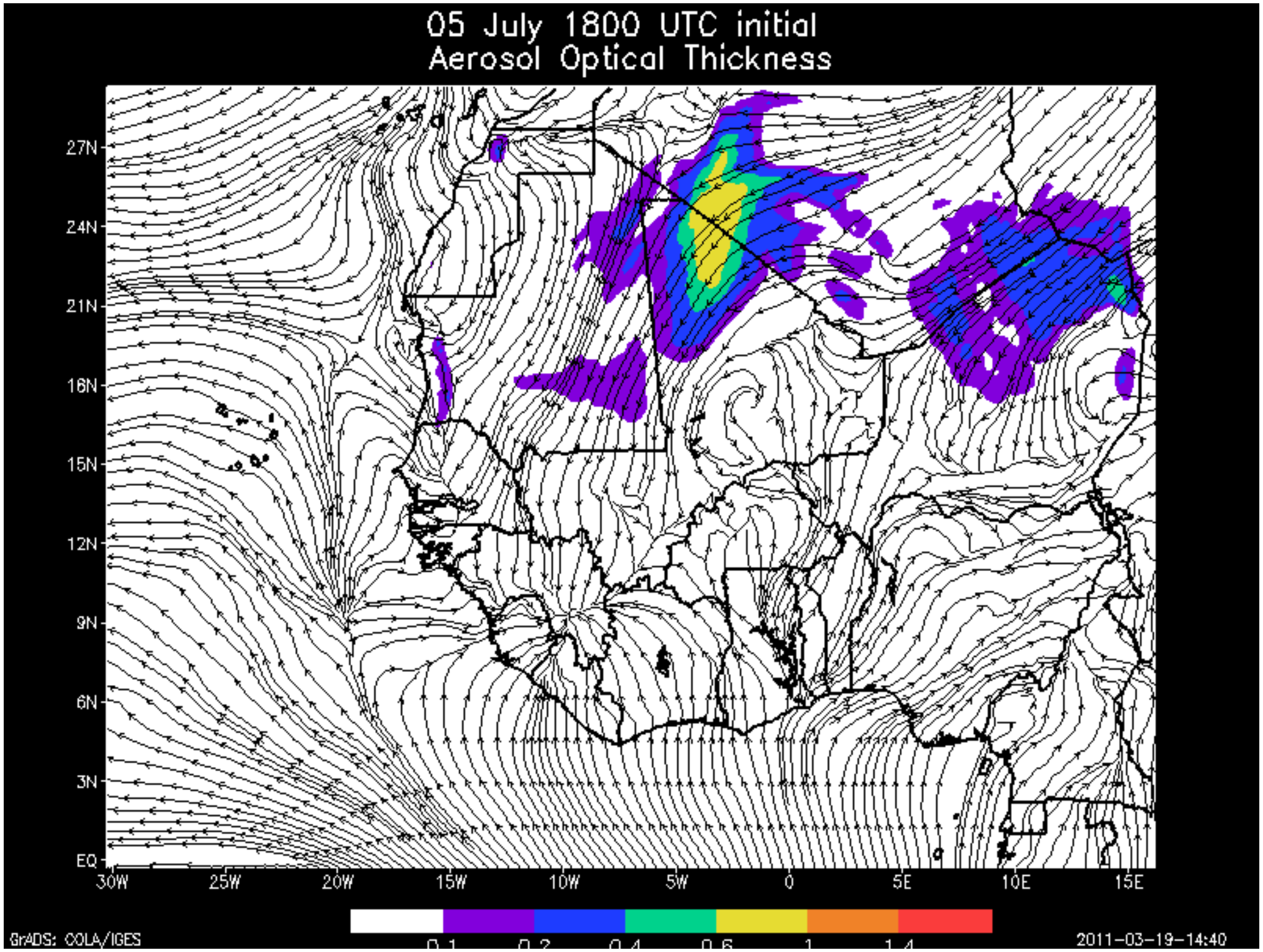
July 5-8 2010 EUMETSAT Dust Product



MET9 RGB-dust 2010-07-05 10:00 UTC

EUMETSAT

Simulated AOD and 925 winds (July 5-8, 2010



Drame et al. 2011

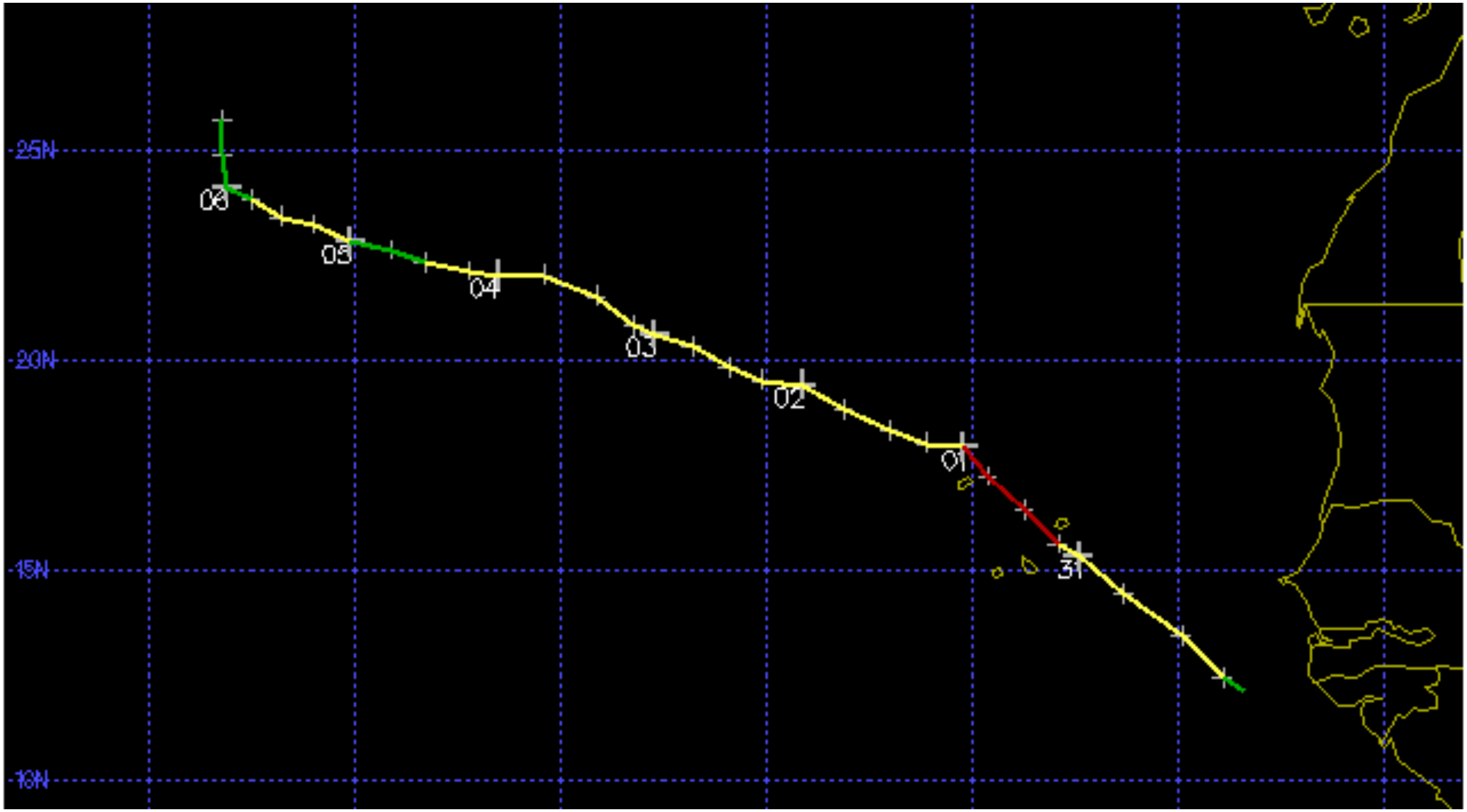
Threatened zone by tropical disturbances

Tropical Disturbance Predictability challenges

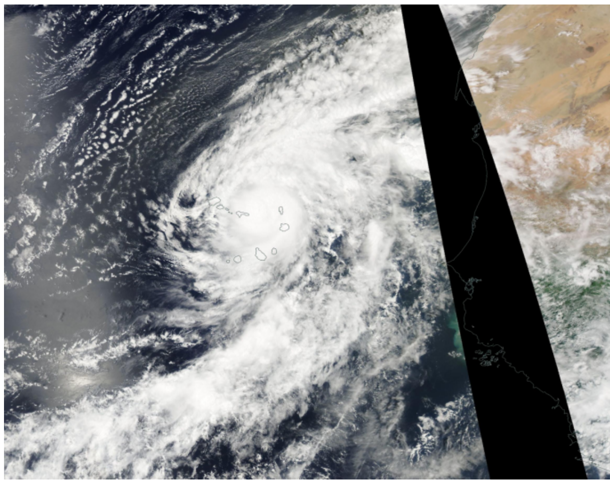
Predictability goal: 48-72 days prior to impact

- Coastal West Africa
  - Dangerous seas, rip currents
  - Coastal flooding.
  - Multiple languages and livelihoods
- Cape Verde
  - Tropical Cyclone Impacts
  - Surge
  - Flash flooding and mud-slides
  - Inexperience population with
- AEWs are well forecasted but TC Genesis is a challenge

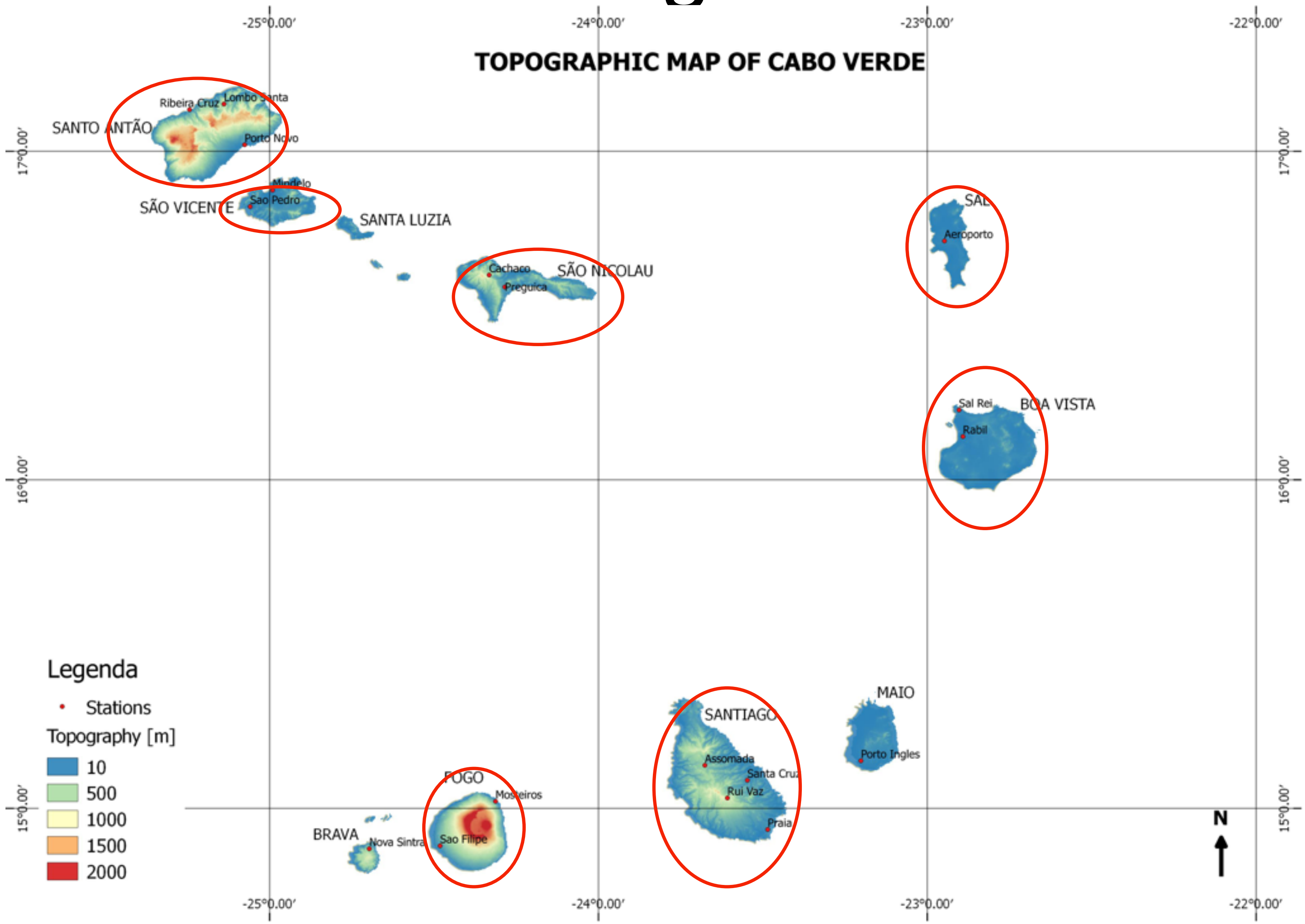
Track of Hurricane Fred



Vulnerable populations in coastal West Africa and Cape Verde



Cape Verde Islands and Fred Damages



Hurricane Fred August 31 2015, Challenges

- Language (Portuguese)
- Experience – None (1st hurricane to strike country)
- Mountains and flash flooding
- 10 Islands (fishermen, tourism) – storm surge.
- No Radar for observing circulation or rain-bands in real-time– what to communicate to other islands?
- Cone of uncertainty includes most of the Islands.

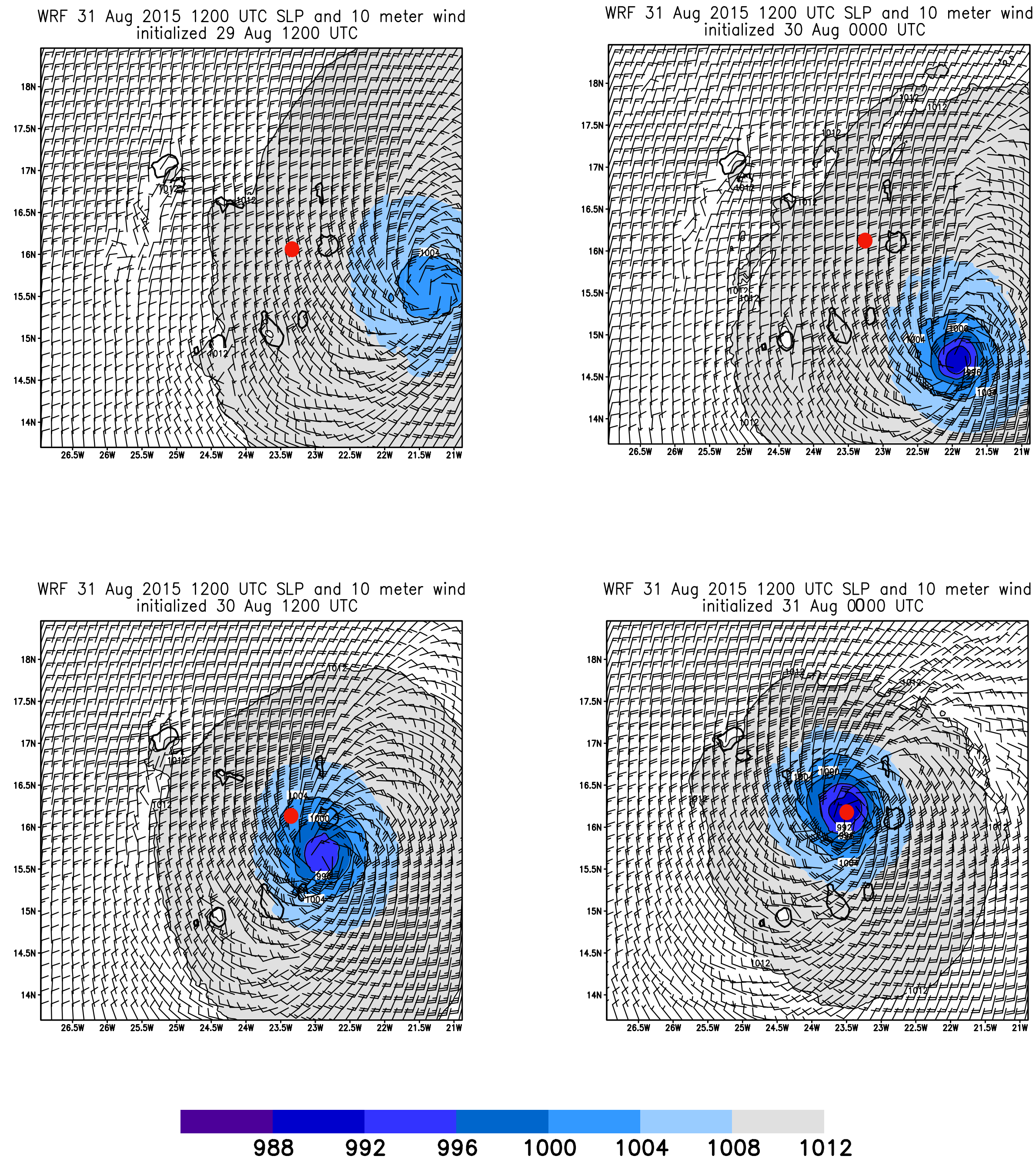
Summary of Events

- African Easterly Wave identified on August 27 as source of Hurricane Fred
- August 29 Disturbance emerges off the coast
- August 30 NHC declares Tropical Storm Fred
- August 31 Hurricane Fred impact Cape Verde
- Forecast suggested some type of impact 5 days before the Island fall
- We went into action on August 28, contact government on August 29, Text messages sent country wide on 30 August.
- August 30 --Evacuation of some vulnerable communities in Sal (living in shanties)

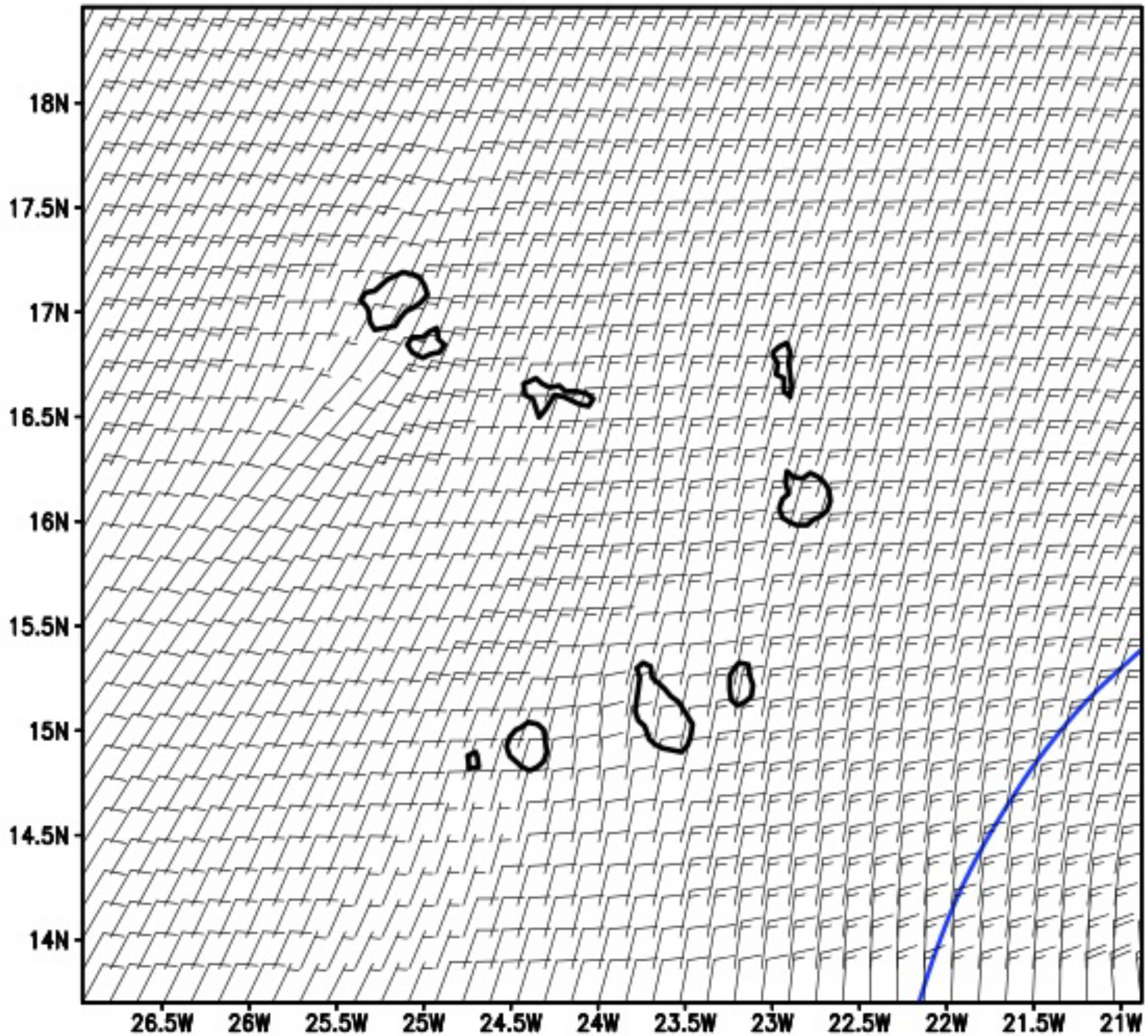
WRF Forecast for Cape Verde from SJSU (S. Chiao)

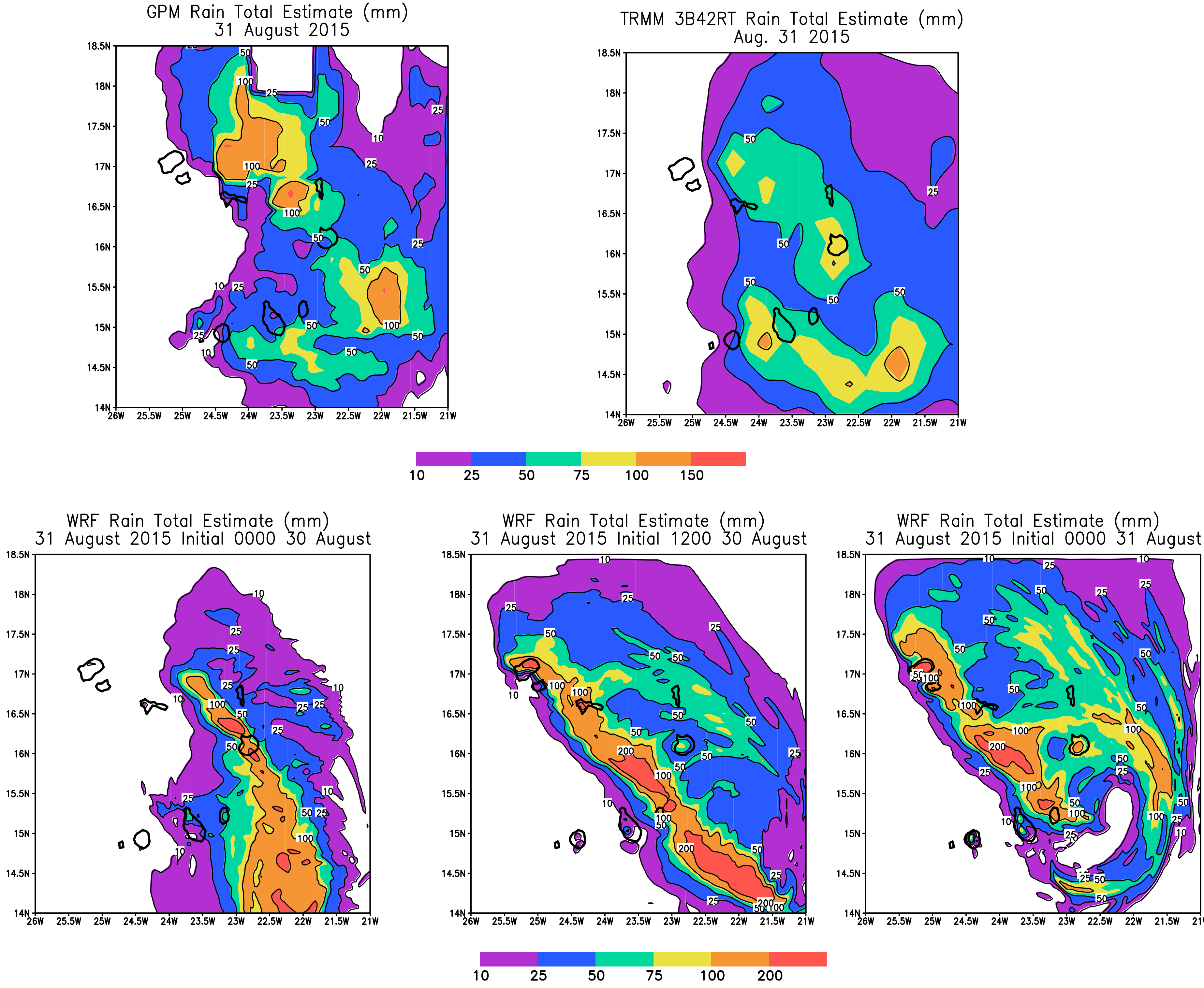
- WRF Version 3.4
- Parent domain
  - 283 east-west points, 181 north-south points, 30 vertical levels, 12 km grid spacing
  - Kain-Fritsch cumulus param, Thompson Microphysics
- Domain 2 (centered on Cape Verde) – 2 way feedback
  - 197 east-west points, 161 north-south points, 30 vertical levels, 3 km grid spacing.
  - No cumulus param, thompson

12-48 hr WRF 3 km forecast of Fred



AUG 30 1200 UTC simulated Max. Reflectivity
SLP and 10 meter wind initialized 30 Aug 1200 UTC




GPM Rain Total Estimate (mm)
31 August 2015
TRMM 3B42RT Rain Total Estimate (mm)
Aug. 31 2015
10 25 50 75 100 150
WRF Rain Total Estimate (mm)
31 August 2015 Initial 0000 30 August
WRF Rain Total Estimate (mm)
31 August 2015 Initial 1200 30 August
WRF Rain Total Estimate (mm)
31 August 2015 Initial 0000 31 August
10 25 50 75 100 200

Summary

- Natural disasters and the numbers of people being affected in Africa is rising.
- Predictive models will become increasing more important now and throughout the 21st century as an adaptation strategy
- More observations are needed but must make use of satellite observations over Africa to improve forecasts of hazards.

Summary - Hazard Prediction

1. Saharan dust storms – mid range forecasts (3-5 days) are promising (summer and winter). Assimilate of satellite (AOD) and surface dust concentrations improves initial conditions.
2. Tropical Disturbances for coastal regions and Cape Verde (48 hours) possible.
   - Use of other models (surge, coastal flooding, flash flooding) needed by operational forecasters.
   - Assimilation of IR radiances of AEWs and ensemble forecast, CYGNSS data (2017) needed to assist in prediction.

Summary

3. Mesoscale Convective Systems – need reliable short term QPF forecasts needed ASAP.

- Assimilation of IR radiances for improving initialization of moisture and convective initiation needs investigation