

OVERVIEW of NRL/FNMOC AEROSOL VALIDATION METHODS



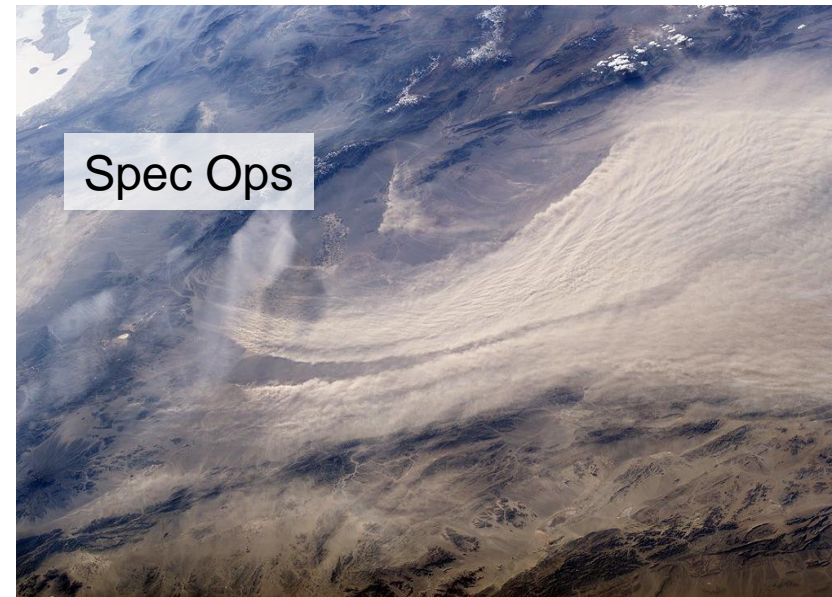
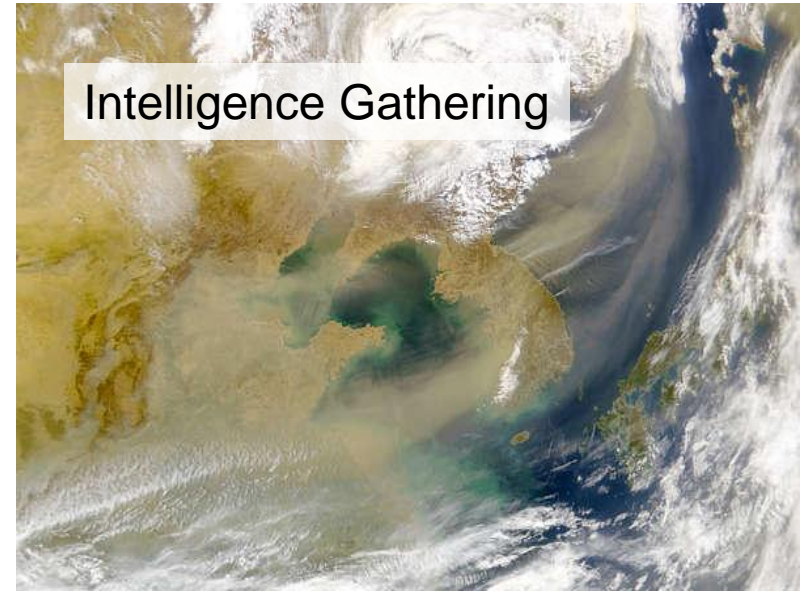
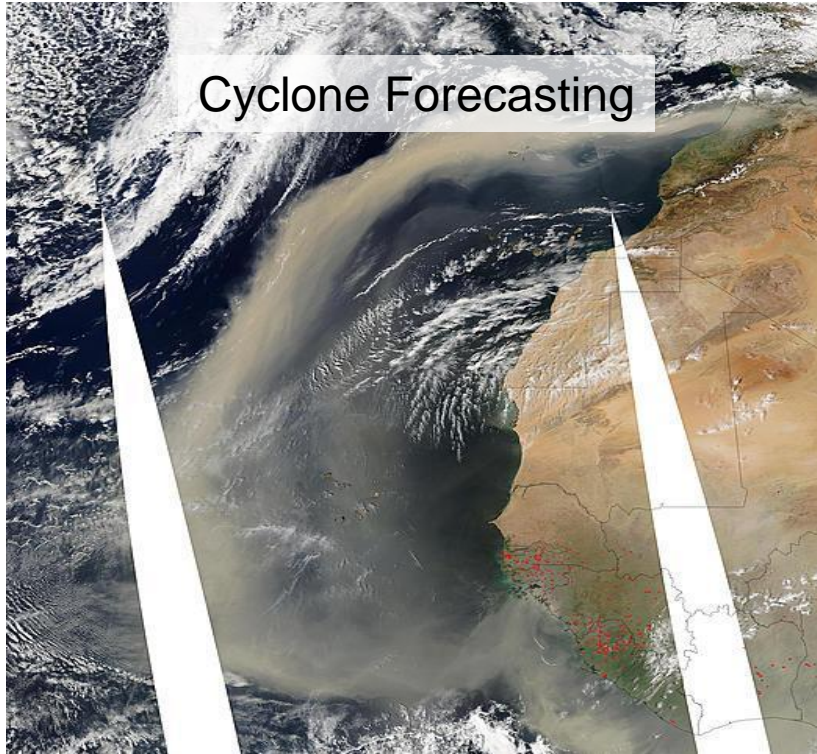
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Aerosol Impacts on Navy Activities



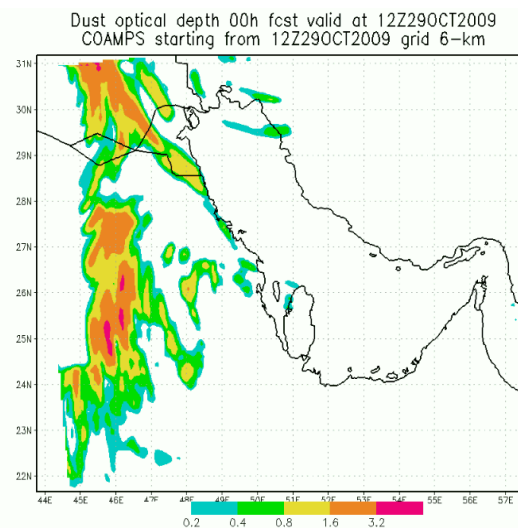
Radiative transfer in the atmosphere at UV, Vis, and IR wavelengths is a major concern

Operational Status of Models

- **NAAPS** global aerosol forecast, operational at FNMOC, 6-day forecast, four times a day
- **COAMPS** regional aerosol forecast, operational for SW Asia, 3-day forecast, twice a day
 - 18-km SW Asia, 6-km PG, 6-km Afghanistan
- **FLAMBE** fire detection, operational, four times a day
- **NAVDAS-AOD** 2D-VAR Aerosol DA, operational, four times a day
- **FAROP** operational, four times a day, derives optical properties



COAMPS forecast of dust plumes 12Z 29 October, 2009



NAAPS COMPARISON TO AVHRR AOD

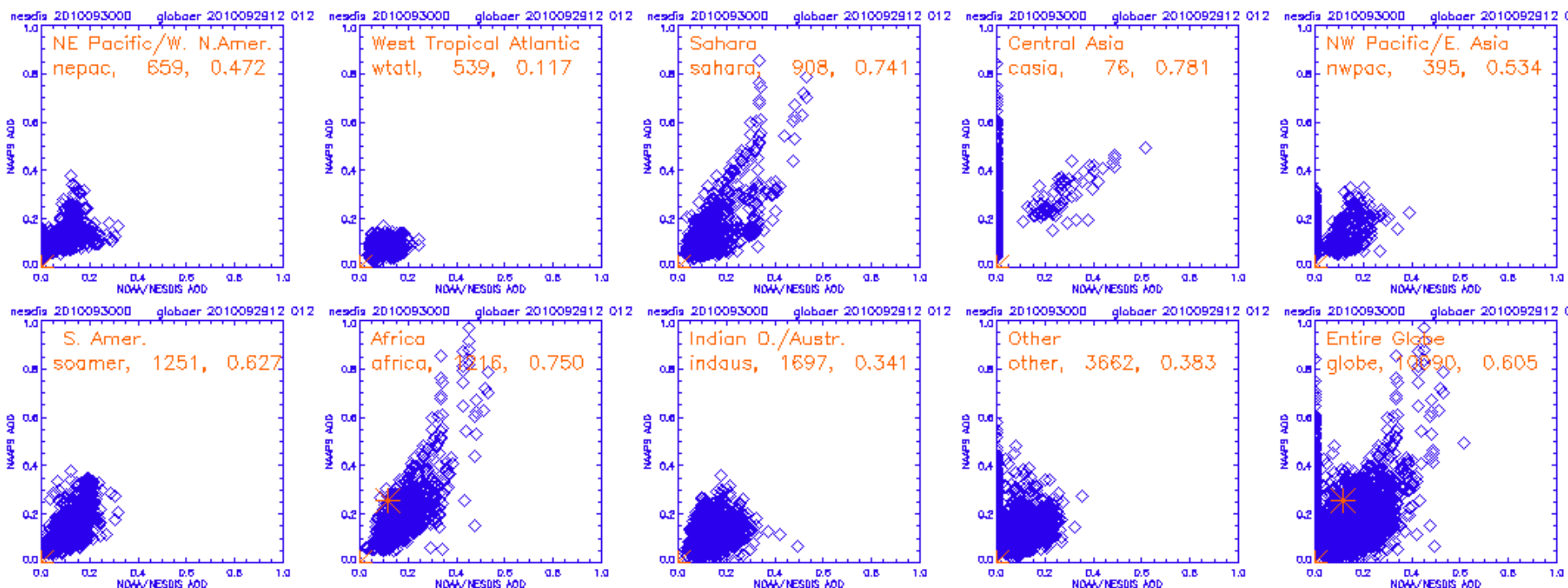
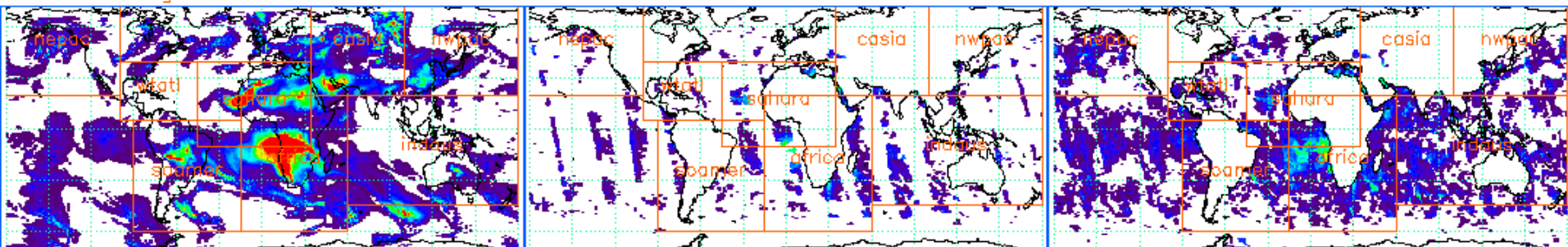


Use for monitoring of model behavior regionally

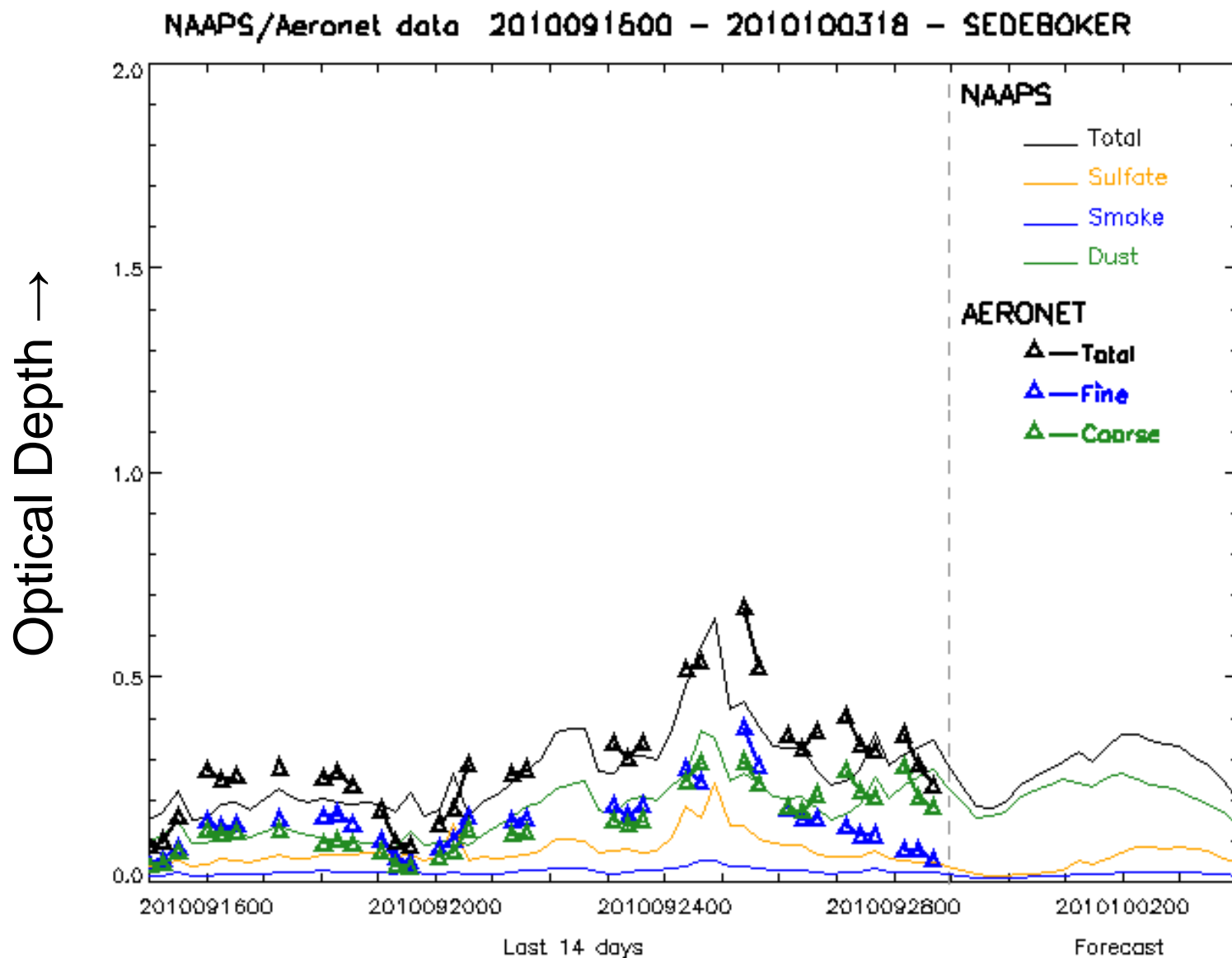
globaer 2010092912

nesdis 201009300701 within 012h of 2010092912

nesdis 201009300701



NAAPS Station Monitoring: 14 days at Sede Boker

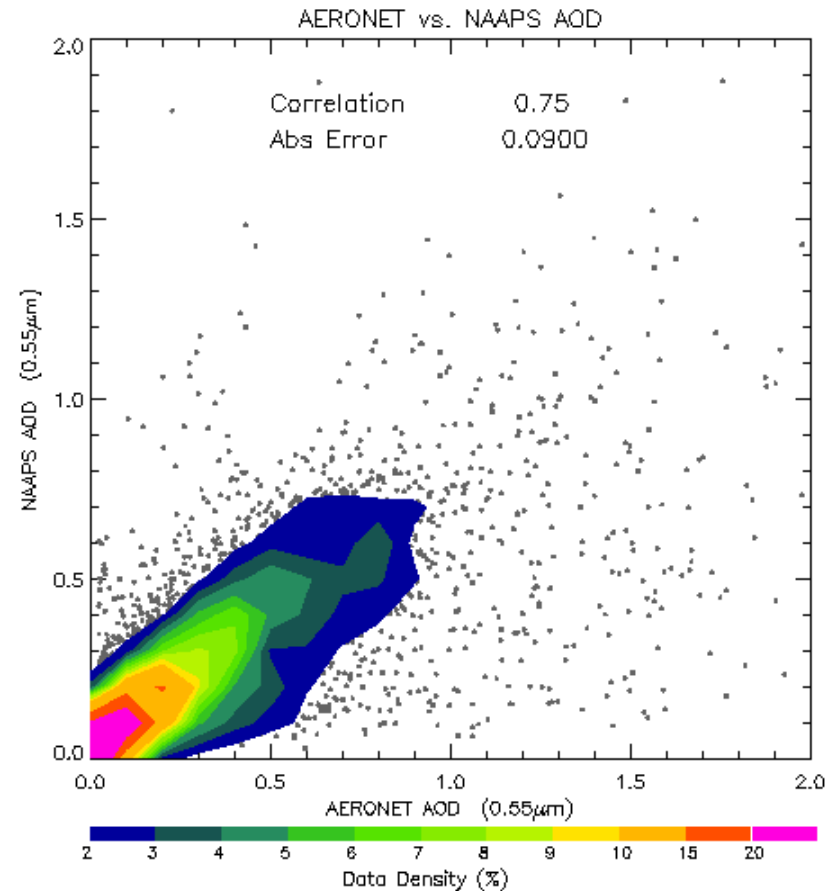
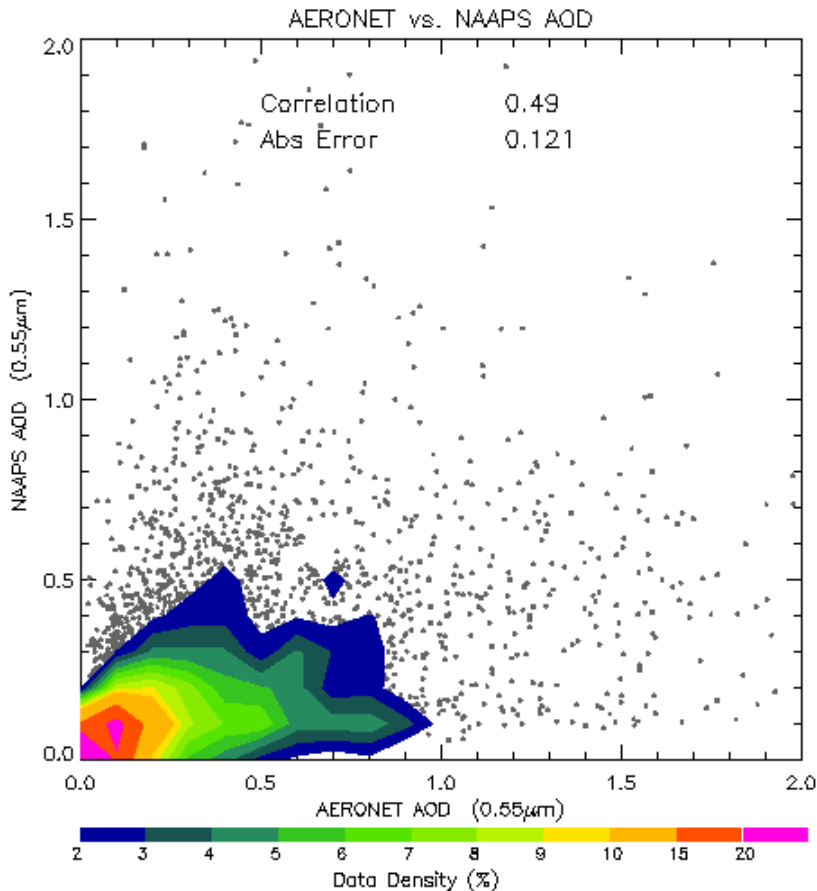


AERONET Used to Monitor Impact of Data Assimilation



Natural run

**+ Land/Ocean MODIS
+ Land/Ocean MISR**

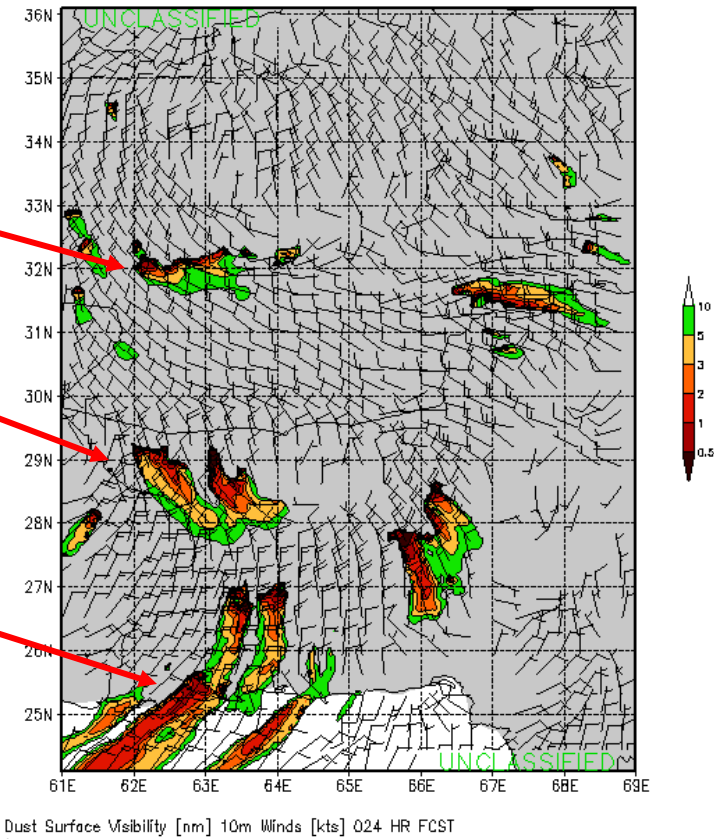
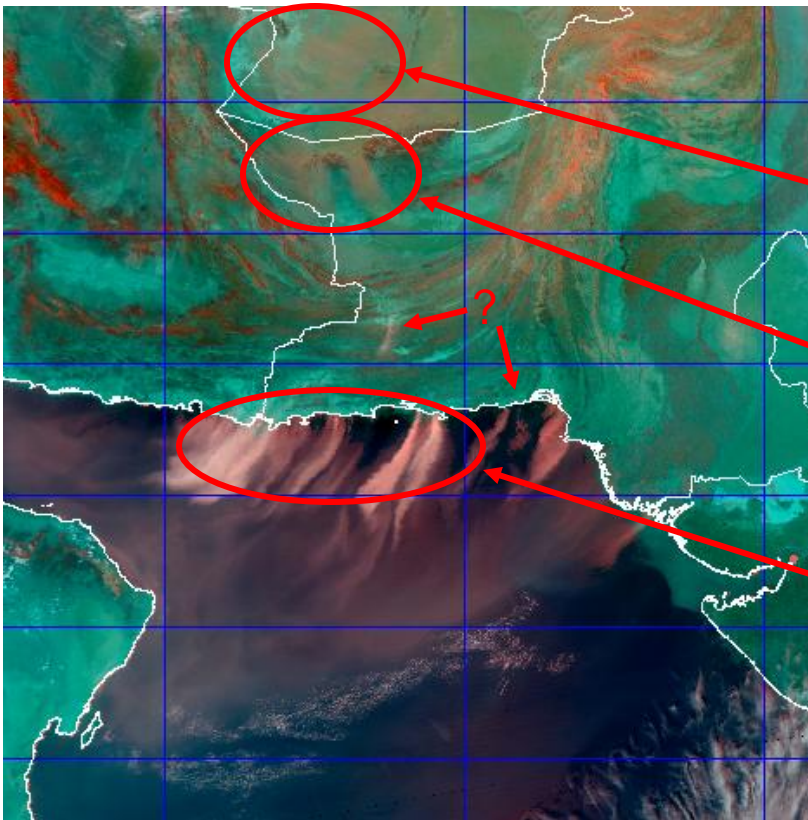


Information available regionally and over different time periods

COAMPS: Forecasting Individual Dust Plumes



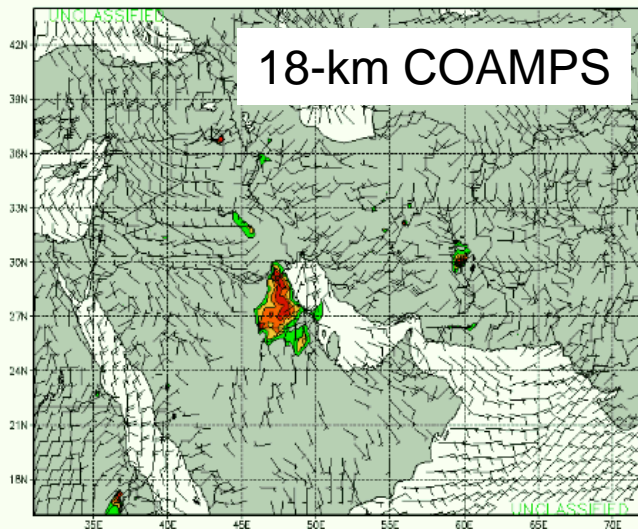
Qualitative validation



Dust Enhancement Product (DEP; FNMOC) for 1330 GMT 9 Nov, 2009

COAMPS 6-km Dust 24-h Forecast (FNMOC) for 1200 GMT 9 Nov, 2009

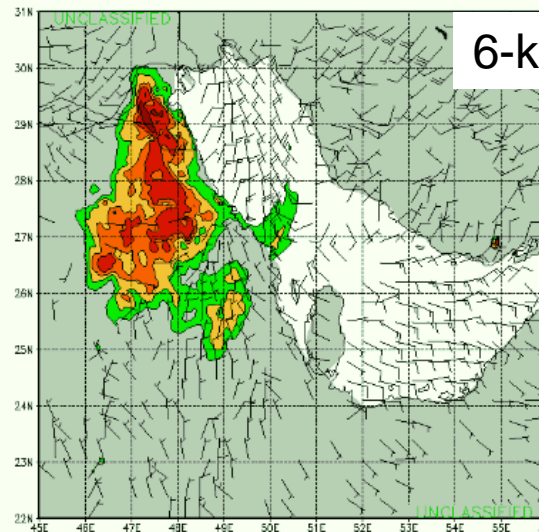
48-hour Dust Model Comparison Side-By-Side: Requested by forecasters



18-km COAMPS

VF: Tue 00Z 26 JAN 10
 FNMOC 18km COAMPS (U): Dust Surface Visibility [m] Winds [kts] 012 HR FCST
 Run: 2010012512Z Tau: 12

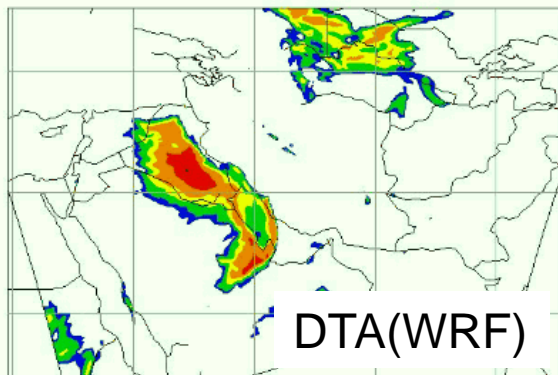
approved for public access. Distribution is unlimited



6-km COAMPS

VF: Tue 00Z 26 JAN 10
 FNMOC 6km COAMPS (U): Dust Surface Visibility [m] Winds [kts] 012 HR FCST
 Run: 2010012512Z Tau: 12

approved for public access. Distribution is unlimited

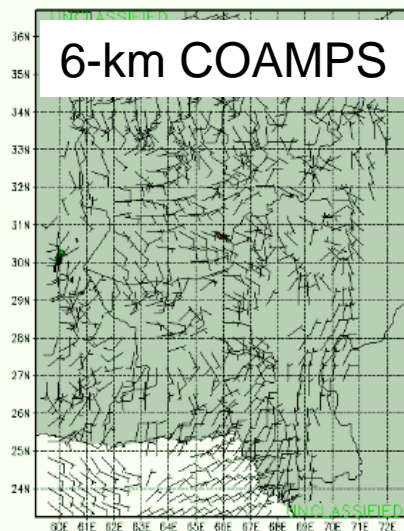
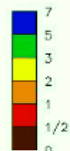


DTA(WRF)

Visibility 100 m above ground level (miles).

AFWA DTA-WRF Model Theater 4b 15km grid, Ginoux-2009 source model

26-Jan-10
 Tuesday
 0000Z
 U.S. Air Force
 Weather Agency
 Initialization Time
 2010 Jan 25 12:00



6-km COAMPS

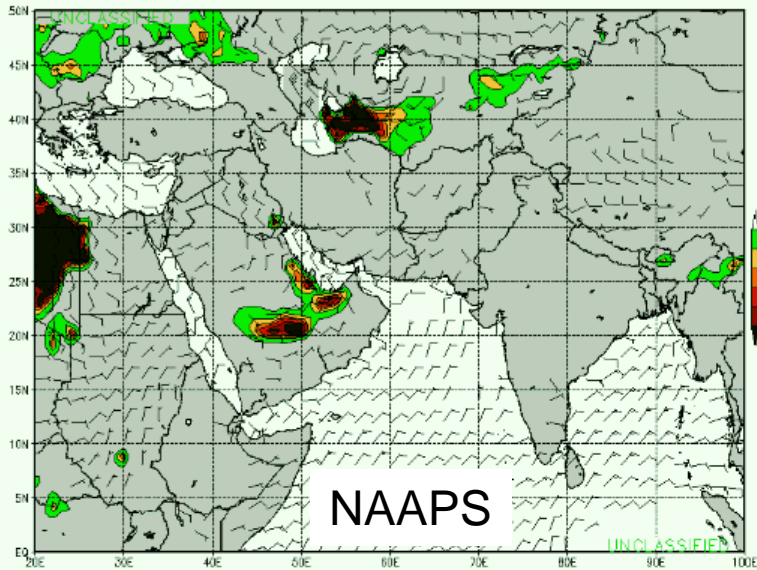
VF: Tue 00Z 26 JAN 10
 FNMOC 6km COAMPS (U): Dust Surface Visibility [m] Winds [kts] 012 HR FCST
 Run: 2010012512Z Tau: 12

approved for public access. Distribution is unlimited

Qualitative comparison

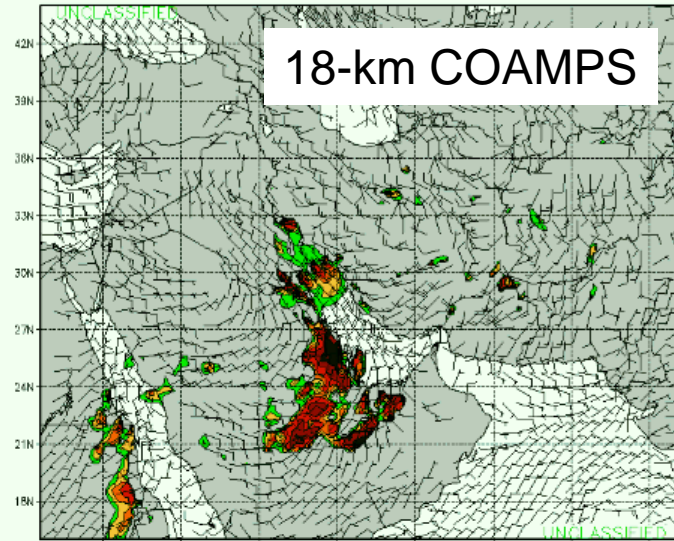
144-h Dust Model Comparison

Forecasters also request quantitative comparison



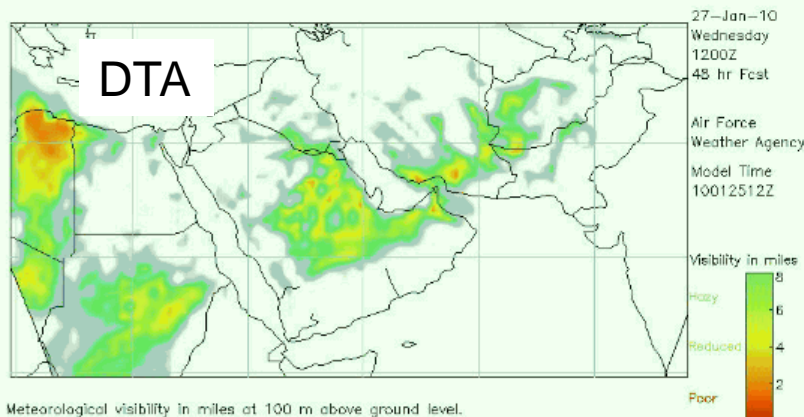
VF: Wed 12Z 27 JAN 10
 FNMOC FARCP (U): Aerial Surface Visibility [m] Winds [kts] 048 HR FCST
 Run: 2010012512Z Tau: 48

Approved for public ocean. Distribution is unlimited



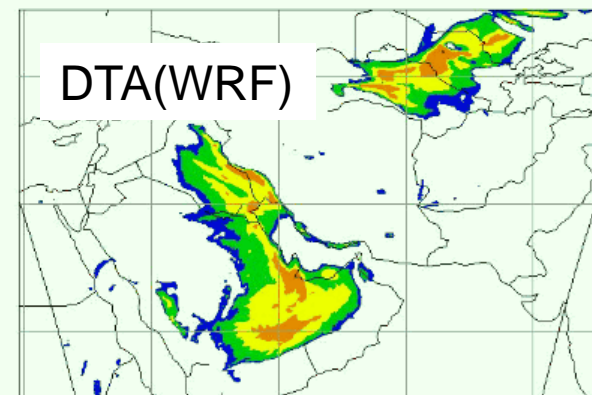
VF: Wed 12Z 27 JAN 10
 FNMOC 18km COAMPS (U): Dust Surface Visibility [m] Winds [kts] 048 HR FCST
 Run: 2010012512Z Tau: 48

Approved for public ocean. Distribution is unlimited



Meteorological visibility in miles at 100 m above ground level.

DTA-AGRMET Map regions with yellow or red should alert the user of conditions of reduced visibility caused by dust. Refer to the "Info" file for preliminary guidance on using this product.



Visibility 100 m above ground level (miles).

AFWA DTA-WRF Model Theater 4b 15km grid, Ginoux-2009 source model

27-Jan-10
 Wednesday
 1200Z
 48 hr Fcst
 Air Force
 Weather Agency
 Model Time
 10012512Z
 U.S. Air Force
 Weather Agency
 Initialization Time
 2010 Jan 25 12:00



Quantitative Verification



Quantitative verification can be done using prediction rates taken from quantitative precipitation forecasting:

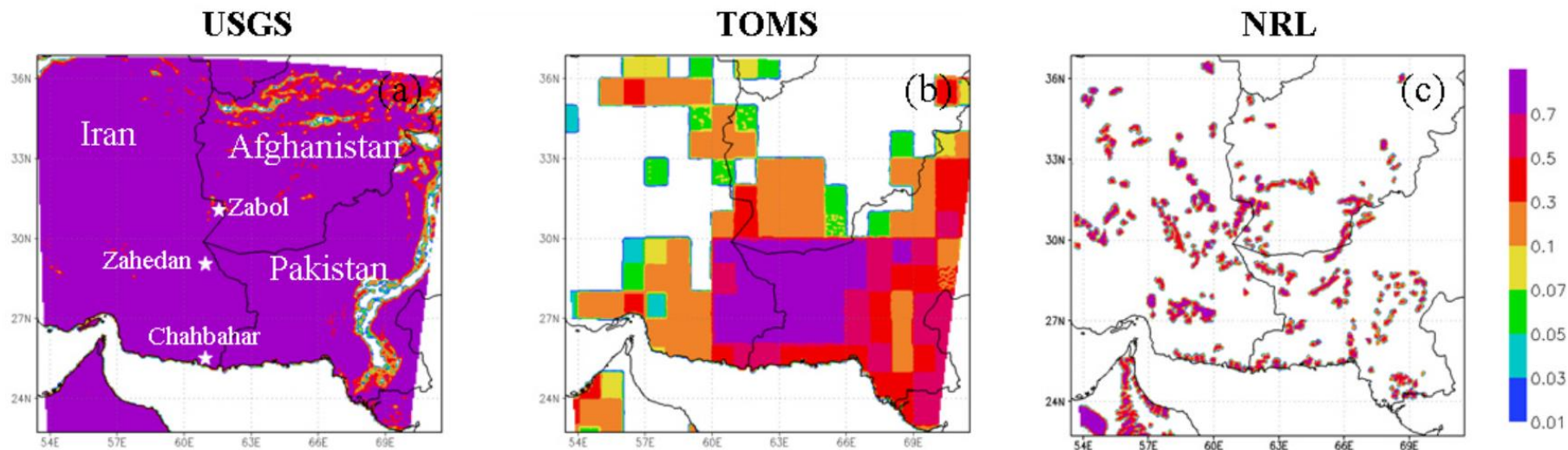
1. **dust storm prediction rate:** number of correctly predicted dust incidents/number observed dust incidents,
2. **dust storm false alarm rate:** ratio of number of falsely predicted dust incidents to number of observed clear-sky, incidents
3. **dust storm threat score:** (number of predicted dust incidents)/(predicted dust + missed dust + false alarm dust incidents)
4. **total prediction rate:** (number of correctly predicted dust incidents + correctly predicted clear-sky incidents)/(total observations).

'Dust Storm' is defined as visibility less than 3.5 km

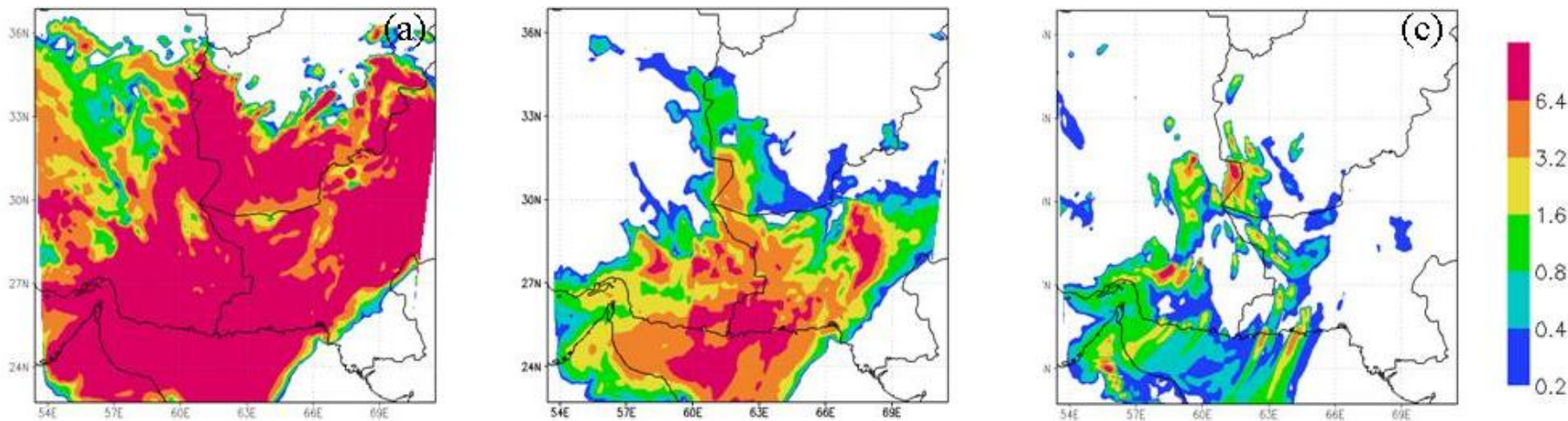
Quantitative Validation Required to Evaluate High-Resolution Dust Source Database in COAMPS

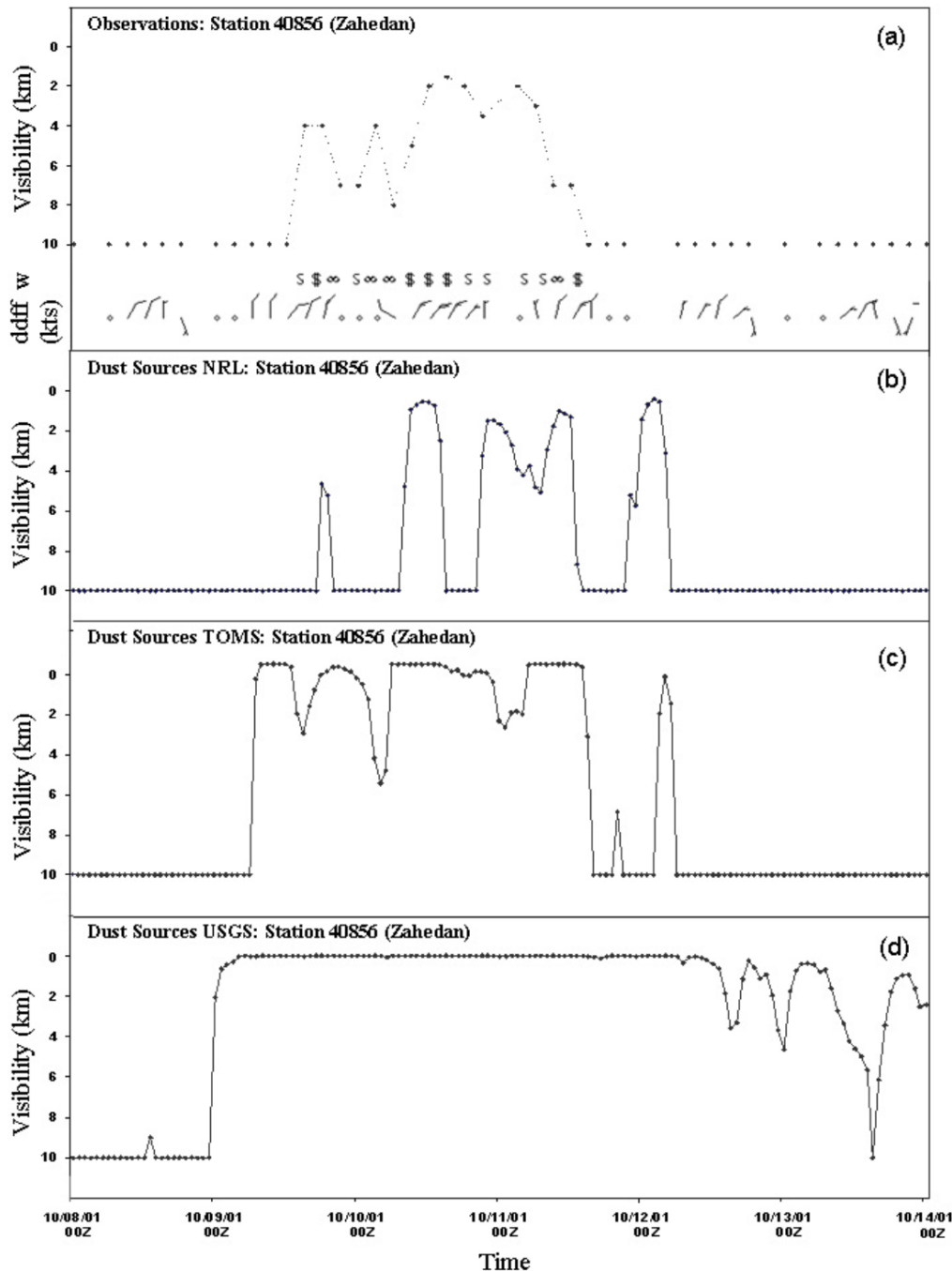


Erodible Fraction on 9-km COAMPS grid derived from DSD



Forecasted Mass Load (mg m^{-2})





• **Visibility reports adequate for V&V**

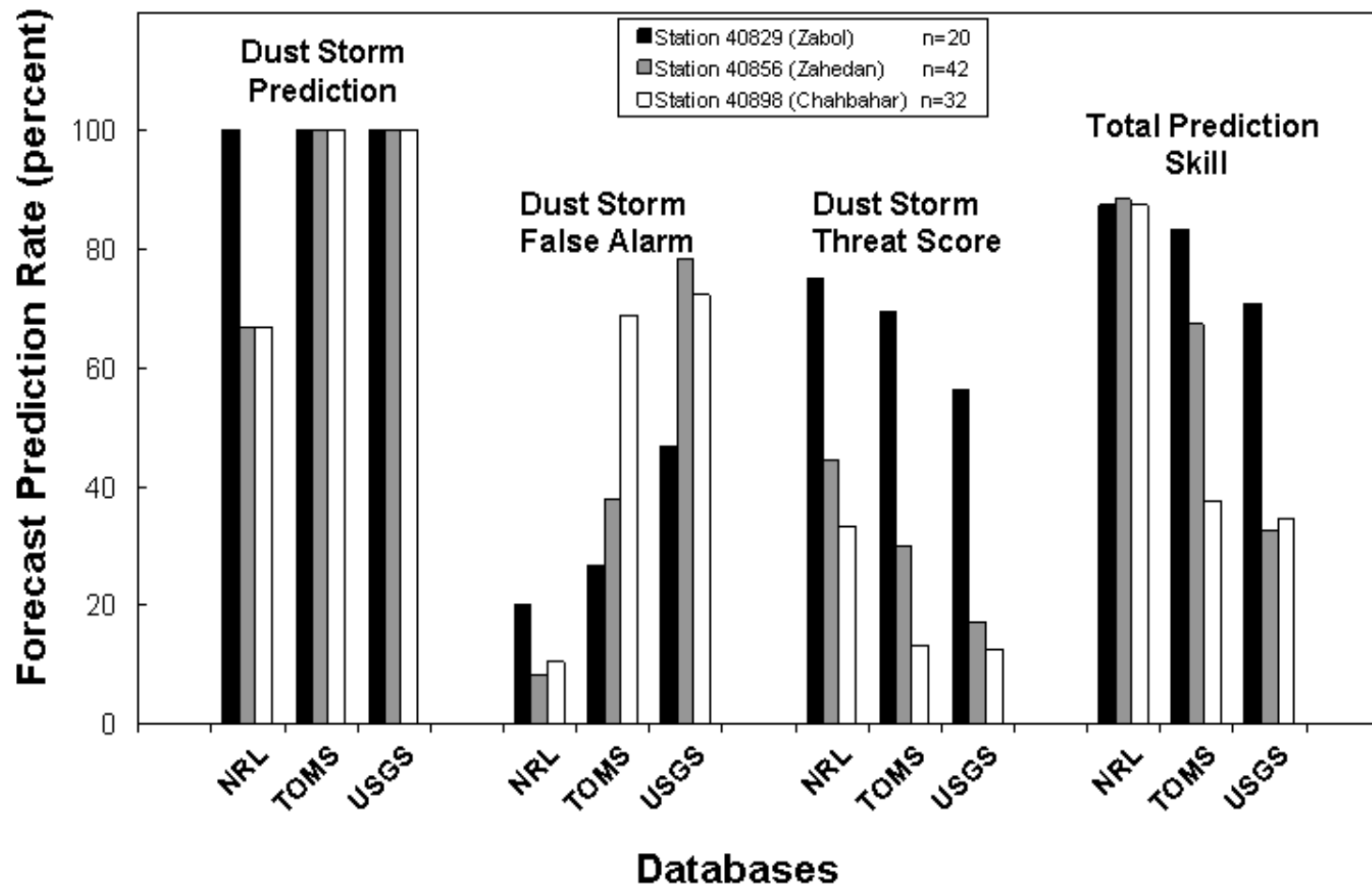
Figure 9. Time series of observed (a) visibility, weather type, and winds at Zabol, Iran from 00Z October 8-14, 2001. For explanation of weather symbols see Table 3. (b) COAMPS forecasted visibility on the 9-km grid at Zabol, Iran from 00Z October 8-14, 2001 using NRL, (c) TOMS, and (d) USGS dust sources databases. Note the inverted visibility (y) axis.

Quantitative Measure of Impact of the Use of DSD in COAMPS



Forecast Skill Scores:

- All improved with implementation of DSD





Dynamics are Largely Forgotten

- On multi-day time-scales, AQ is dominated by sources, mixing, transport, and removal, all with strong dynamical dependence
- Validation is required for relevant dynamical properties:
 - T_g ,
 - surface winds, 925 mb winds,
 - TKE, H_{pbl} ,
 - precipitation, cloud fraction, CWV
 - F_{TOA} ,
 - potential temperature, stability
- Leverage the NWP community
 - Use their case studies and results
 - Do enough validation to convince them they have a problem that needs to be solved



Dust Model Intercomparison (DMIP): Looked at dust and dynamics



Table 2. Required Model Output for Dust Model Intercomparison

Variable	Contents	Unit
DFLX	dust emission flux ($d < 20 \mu\text{m}$)	$\text{mg}/\text{m}^2/\text{h}$
DC1B	dust concentration at first model level ($d < 20 \mu\text{m}$)	$\mu\text{g}/\text{m}^3$
DC7H	dust concentration at 700 hPa ($d < 20 \mu\text{m}$)	$\mu\text{g}/\text{m}^3$
DCLN	dust column loading (height $z < 10 \text{ km}$) ($d < 20 \mu\text{m}$)	mg/m^2
WS10	wind speed at 10 m level	m/s
USTR	surface friction velocity	m/s
USTH	threshold surface friction for dust lift up	m/s
PREP	precipitation rate	mm/h
DDRY	dust dry deposition ($d < 20 \mu\text{m}$)	$\text{mg}/\text{m}^2/3 \text{ h}$
DWET	dust wet deposition ($d < 20 \mu\text{m}$)	$\text{mg}/\text{m}^2/3 \text{ h}$

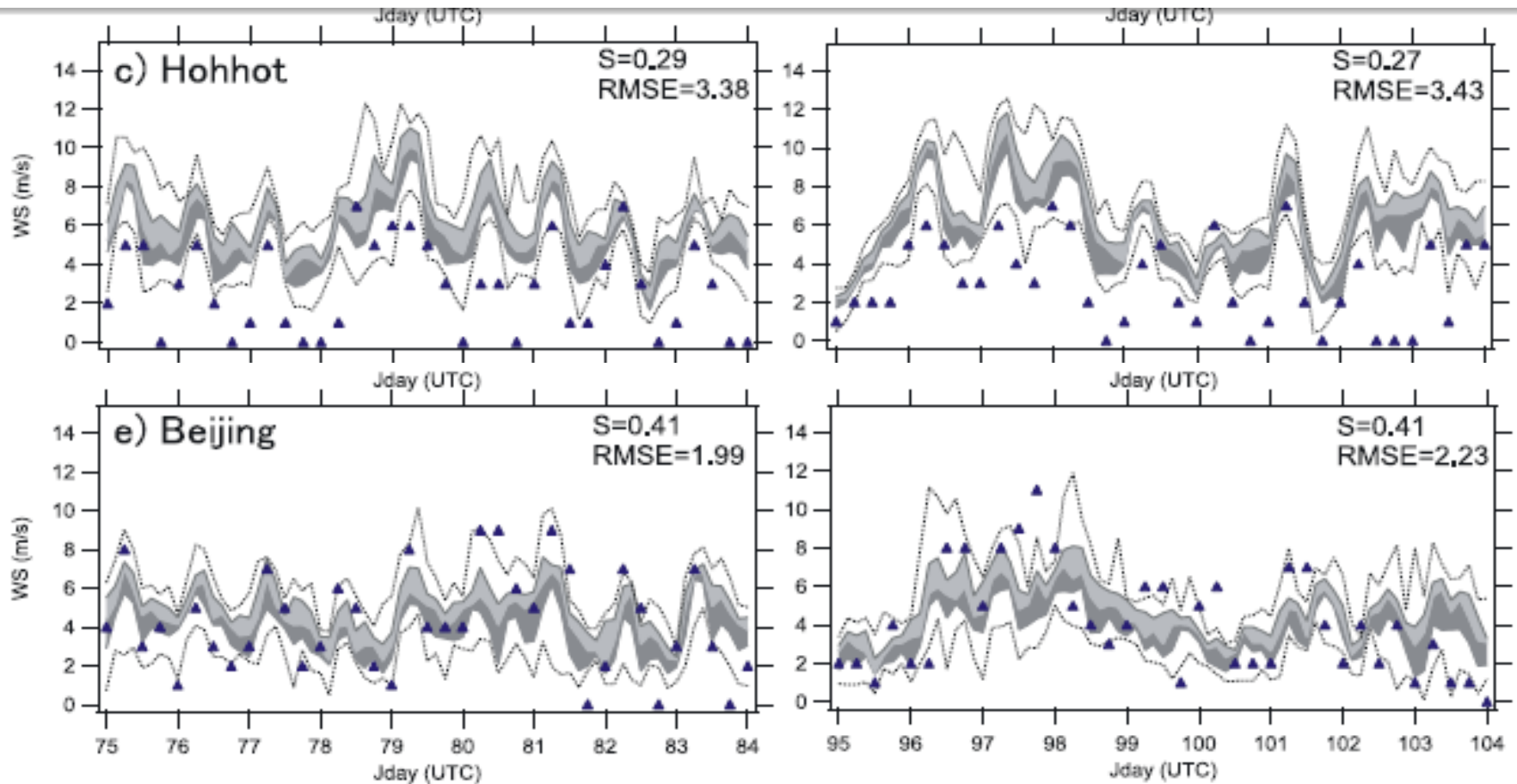


Figure 6. Time variation of wind speed at 10 m height (WS₁₀). Sites are Tazhong, Ejin Qi, Hohhot, Taiyuan, and Beijing. WS₁₀ from each model are shown by min, 25%, 50% (mode), 75%, and max values. Quartile values between the 25% and 75% percentiles are shaded. Triangles show the observed wind speed from SYNOP observation at 6-hour intervals.

Dust Model Intercomparison (DMIP): Sfc. Dust conc. comparison

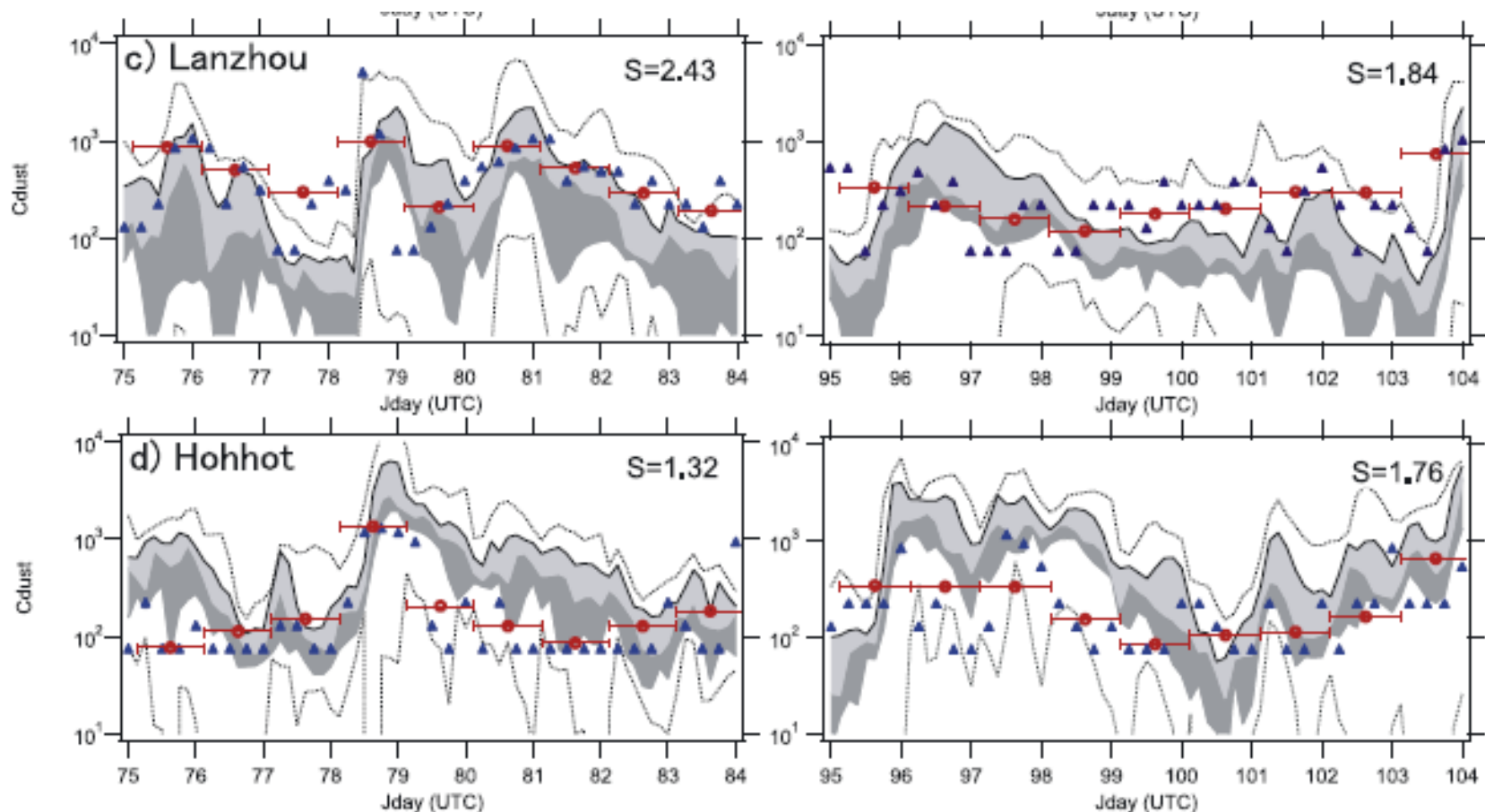


Figure 7. Time variation of the surface dust concentration ($\mu\text{g}/\text{m}^3$). (a) Tazhong, (b) Ejin Qi, (c) Lanzhou and (d) Hohhot. The surface dust concentration from each model is shown by min, 25%, 50% (mode), 75%, and max value. Quartile value between 25% and 75% percentile are shaded. Triangles are observed VC_{TSP} converted from SYNOP visibility. The circles with horizontal bar are daily averaged PM_{10} measurements from the Chinese SEPA sites.

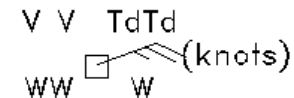
Use of Surface Obs. for Validation



NRL Station Model

- Used to highlight visibility reducing weather related to aerosol events (as cyan)
- Differentiates these events from precipitation events (in green)

Station Model used in Plots of Visibility-Reducing Weather
(used after October 24, 2004)



V V – visibility in cyan color when < 5 km; or ...

– as red dot if greater than 5 km; or no mark when missing

TdTd – dew point depression (deg C) in green when less than 3C (near saturation); or ...

– as red dot if greater than 3C; or no mark when missing

WW – current weather in cyan color for dust, smoke or haze; or ...

– in green color for precipitation and fog; or ...

– as red dot if otherwise; or no mark when missing

WMO	Symbol	Description
4		Visibility reduced by smoke
5		Haze
6		Widespread dust in suspension in the air, NOT raised by wind at time of observation
7		Dust or sand raised by wind, at time of observation
8		Well-developed dust devil(s) within past hour
9		Duststorm or sandstorm within sight of or at station during past hour
30		Slight or moderate duststorm or sandstorm, has decreased during past hour
31		Slight or moderate duststorm or sandstorm, no appreciable change during past hour
32		Slight or moderate duststorm or sandstorm, has increased during past hour,
33		Severe duststorm or sandstorm, has decreased during past hour
34		Severe duststorm or sandstorm, no appreciable change during past hour
35		Severe duststorm or sandstorm, has increased during past hour

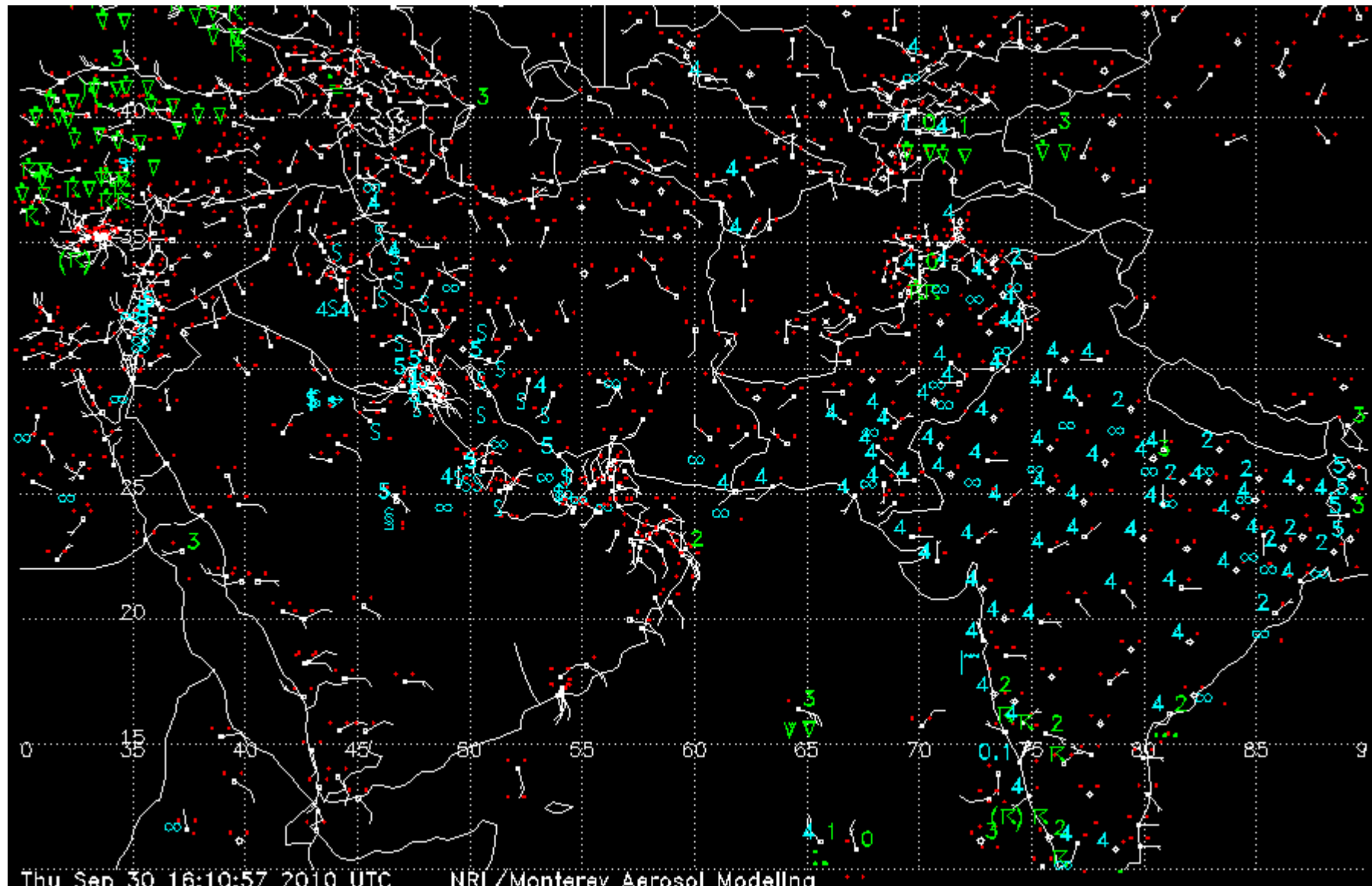
W – past weather in cyan color for dust; or ...

– in green color for precipitation and fog; or ...

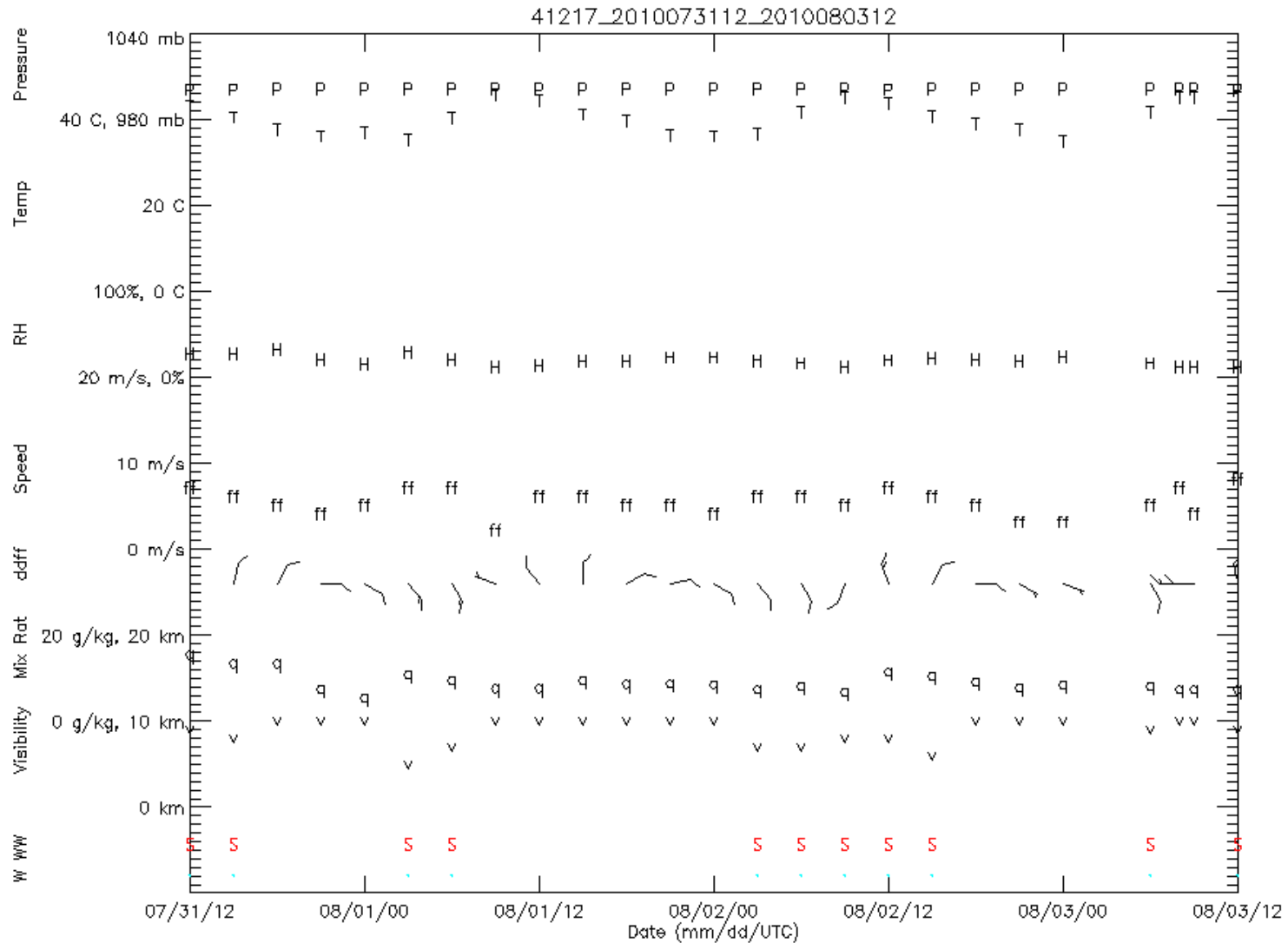
– in red otherwise; or no mark when missing

WMO	Symbol	Description
3		Duststorm or sandstorm, or drifting or blowing snow

Use of Surface Obs. for Validation: Density is sufficient in many regions



Use of Surface Obs. for Validation: High quality stations have consistent reports





Surface Station Filtering

BASE CRITERIA (strict)

- At least 18 months of data
- Reports every 3 hours
- Less than one week of missing values (RH,vis,T) per year
- Correlation between current weather and visibility (ie. heavy fog and clear skies should have different vis)
- No hard visibility maximum at 4 km (India filter)
- Visibility values must have spread
 - Automated stations reporting constant vis not useful

FILTER TYPE	FAILING STATIONS
FREQUENCY	2018
MISSING FIELD	2180
HISTORY	873
SPREAD	2482
TOTAL REMOVED	6159



Surface Station Filtering

BASE CRITERIA

Only successful in China and Europe

RELAXED FREQUENCY

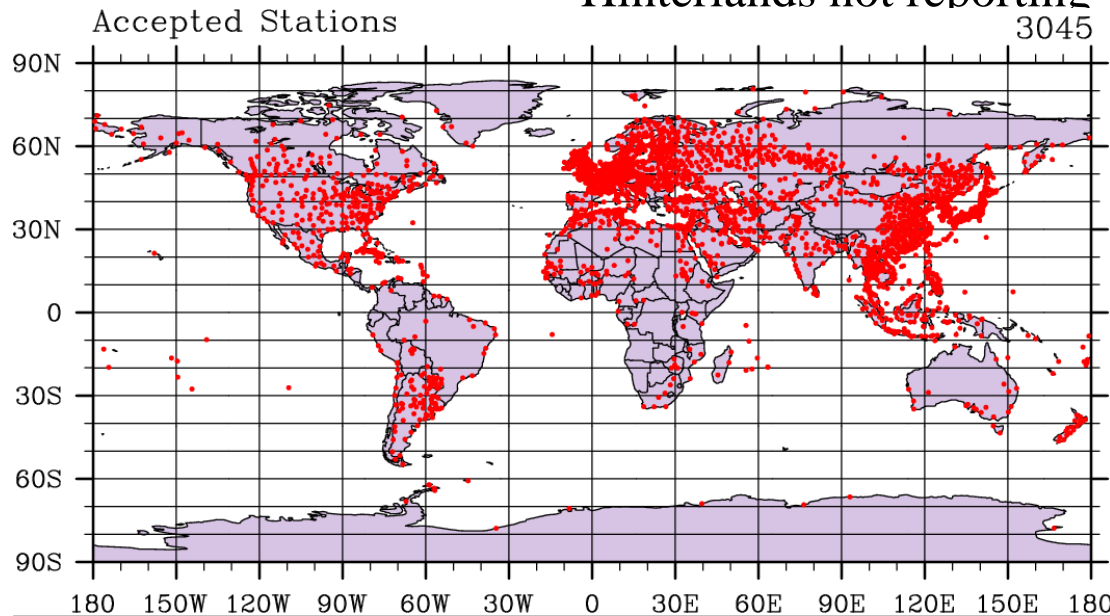
Africa, Americas, Russia, SE Asia, Southern Pacific

Six hourly reports

Australia

Many report only at 05 and 23 UTC

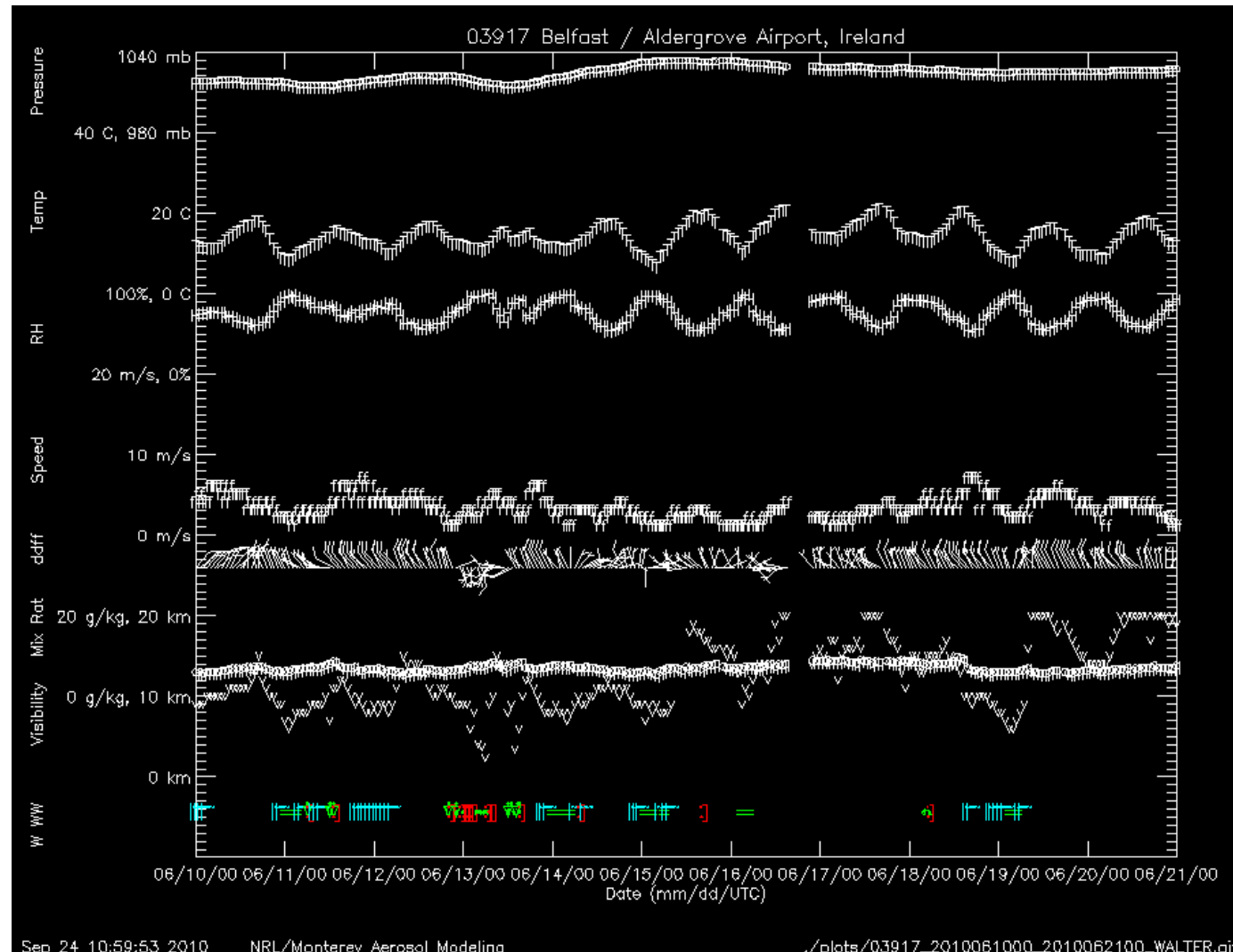
Hinterlands not reporting visibility



Surface Station Filtering

ACCEPTED

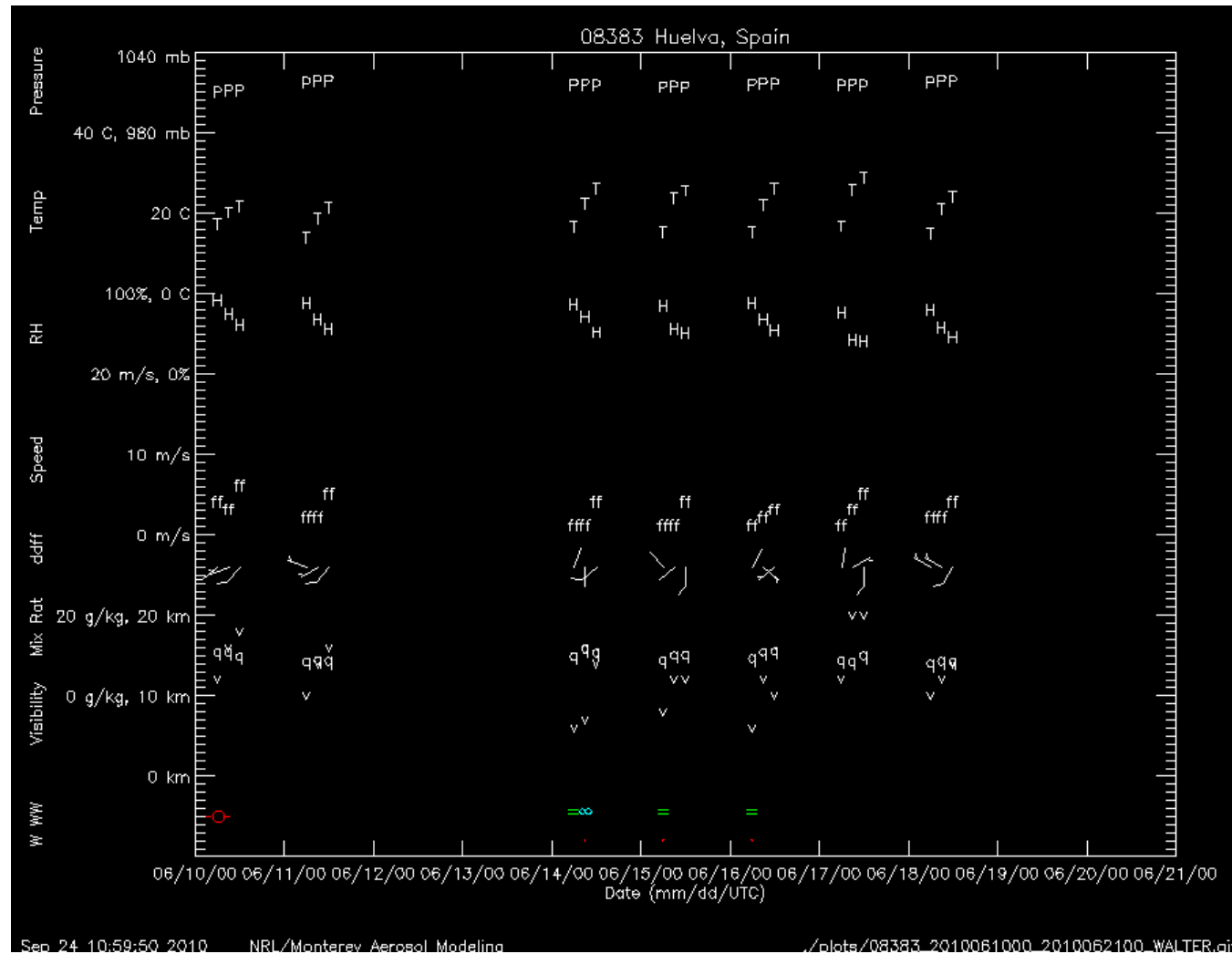
- Regular reporting
- Aerosol obs influencing vis



Surface Station Filtering

REJECTED

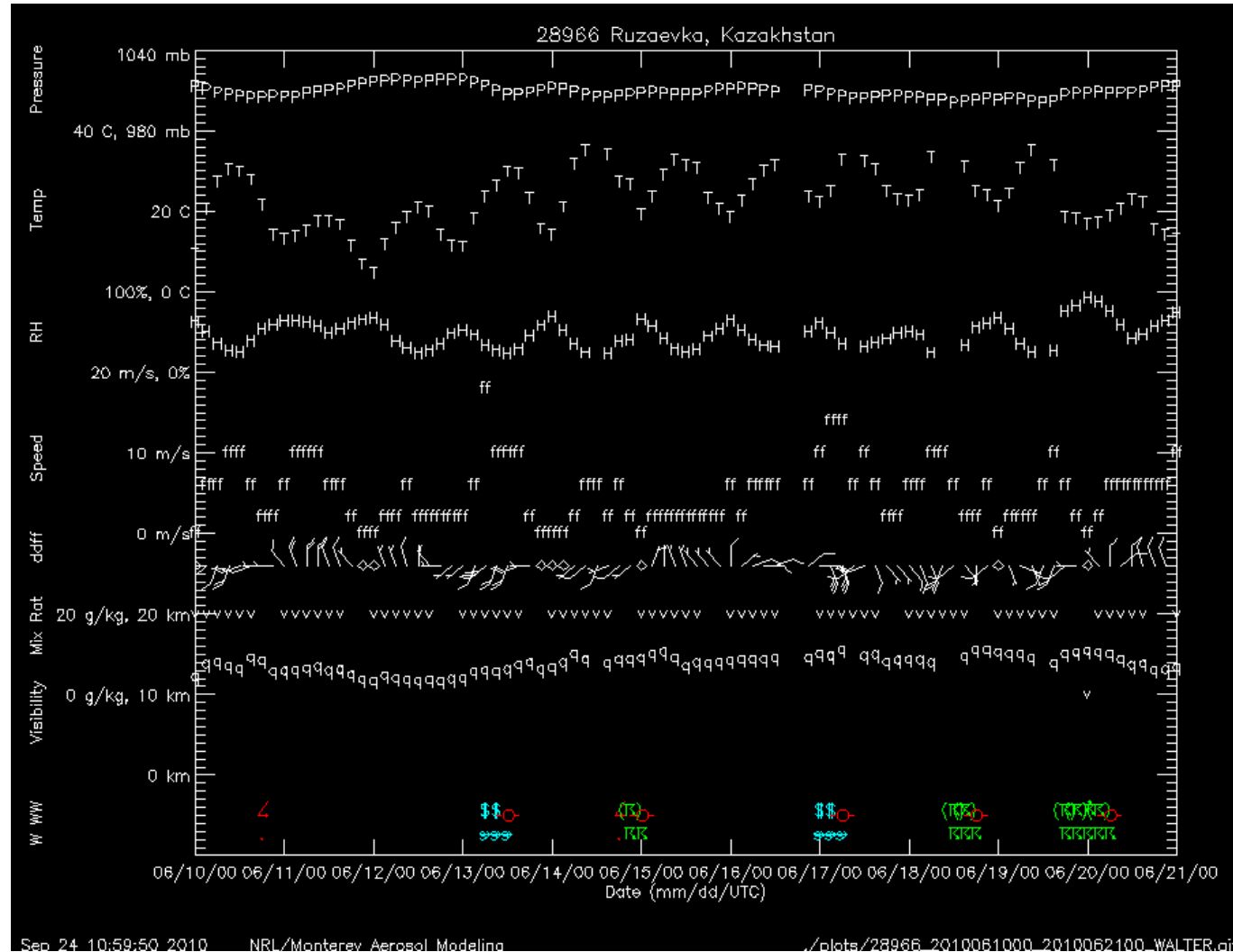
- Visibility and current weather reporting sporadic



Surface Station Filtering

REJECTED

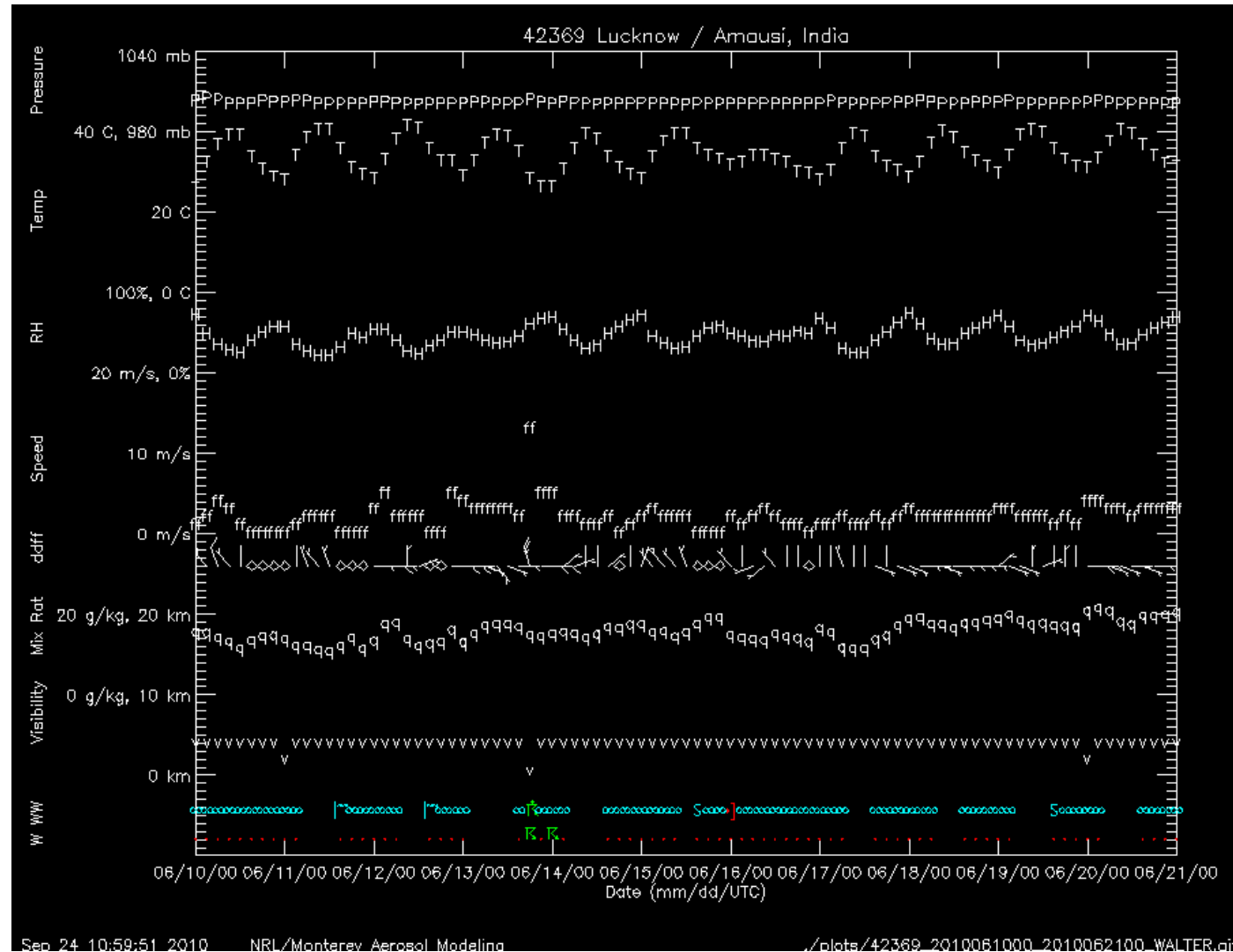
- Dust/Weather and Vis not correlated



Surface Station Filtering

REJECTED

- 4 km Maximum



WMO METEOROLOGICAL WARNINGS STUDY GROUP (METWSG) considering change in definitions



Symbol	Code	Description of present or past weather
☁	4	Visibility reduced by smoke
∞	5	Haze
§	6	Widespread dust in suspension in the air, NOT raised by wind at time of observation
§	7	Dust or sand raised by wind, at time of observation
☁	10	Light fog
§	30	Slight or moderate duststorm or sandstorm, has decreased during past hour
§	31	Slight or moderate duststorm or sandstorm, no appreciable change during past hour
§	32	Slight or moderate duststorm or sandstorm, has increased during past hour
§	33	Severe dust storm or sand storm, has decreased during past hour
§	34	Severe dust storm or sand storm, no appreciable change during during past hour
§	35	Severe dust storm or sand storm, has increased during during past hour

Plan – Add Vis and wind speed criteria to discriminate from LRT.

But Vis and wind speed are already reported and available to user

Real problem – sand storm (dune-related) and dust storm are reported together even though defined differently:
 sandstorm – 10-50 ft altitude, large particles
 dust storm – up to several km altitude, small particles

Decision to be made in Nov.

Summary and Recommendations



Goals

- Specific validation over region for our customers (vis, PM2.5)
- Common validation for our peers (AOD, fluxes)

Situation

- Model intercomparison and V&V are different approaches
- Customers are quite different from center to center:
 - Navy interest is 0-72 hr forecasts of visibility
 - AQ interest is forecasts for health, ozone, PM2.5
- Customers and program managers are interested in model intercomparison
- Underfunded and understaffed
- Each center chooses specific variables, domain, approach
- Select some sites of common interest to different centers
- Select a few variables of common interest for intercomparison
- Real-time easier than retrospective (?)