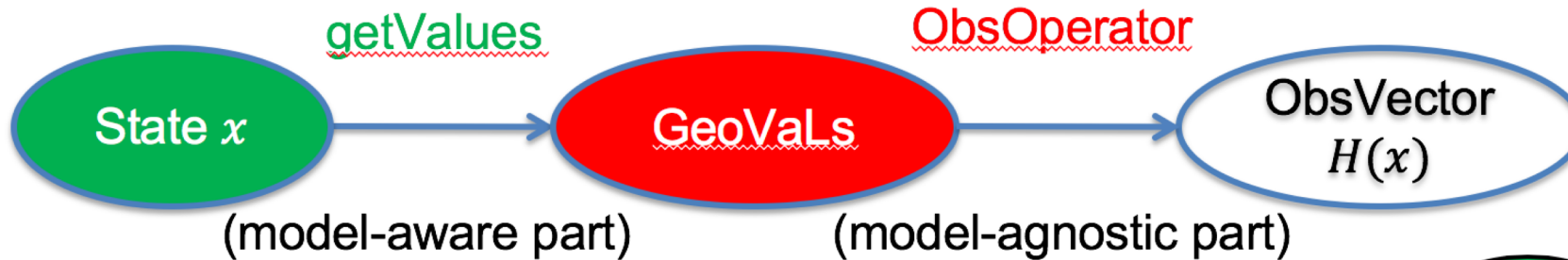


Forward models for surface observations

GSD folks: Stan Benjamin, Ming Hu, Guoqing Ge

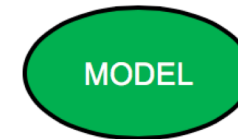
18 July 2019

Interface between Observations and Model

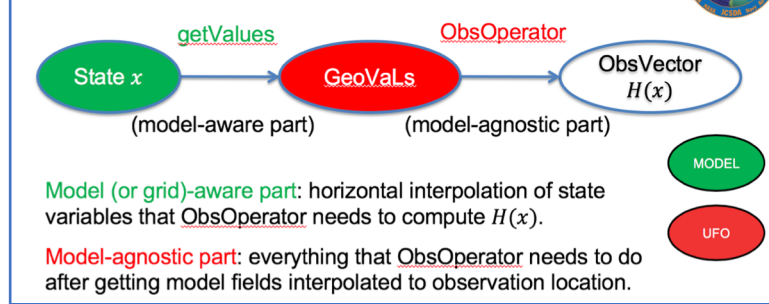


Model (or grid)-aware part: horizontal interpolation of state variables that ObsOperator needs to compute $H(x)$.

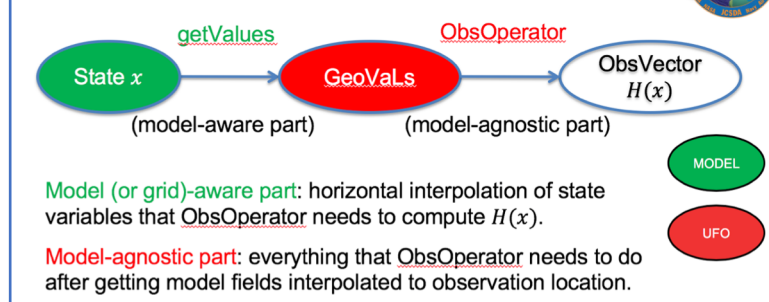
Model-agnostic part: everything that ObsOperator needs to do after getting model fields interpolated to observation location.



General ideas from GSD approach



- 2 parts to forward model for surface obs:
 - Part A - get estimates (T, p, Td, u, v, ...) from model background at explicit 2m/10m height (if available) at *model* elevation but also at different model levels above surface. (likely variables: T, q_v , p, z, u, v)
 - Part B - perform *correction* for elevation difference between model and observation (needed for temperature, dewpoint, pressure)



General ideas from GSD approach

- `getValues` should produce best GeoVaLs estimate of 2m temp, 2m dewpoint, 10m wind (and flexible for station-dependent anemometer height, e.g., 2m or 5m for mesonet stations or buoys)
 - These 2m/10m GeoVaLs should be *relative to model elevation height*. (Part A)
 - `getVaLs` should also include the full profile of T/q/u/v. (to enable Part B)
- `ObsOperator` should then estimate values at **station elevation**. (Part B)
- Part B - Elevation above ground level (AGL) is important in the boundary-layer-relative estimate for
 - Winds – no further change is needed
 - 2m temp – reduction using local lapse rate is required
 - 2m dewpoint – maintain observation T-Td difference (dewpoint depression)

Forward model for surface obs in GSI (GSD treatment) –

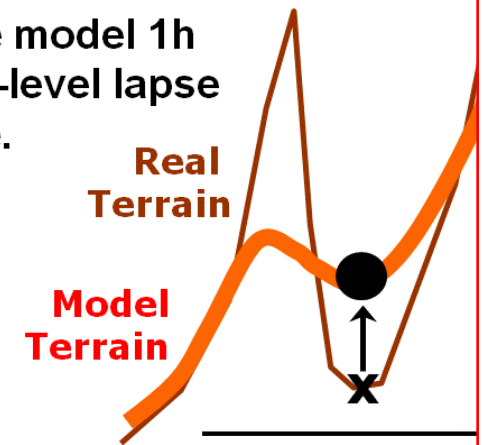
- adjust initial GeoVaLs (at model elevation -Part A) to new values at *obs* elevation (Part B)
- 2m temperature
 - Use local lapse rate (lowest ~ 60 hPa) from 1h forecast
 - Defined in GSI routine *gsd_terrain_match_surfTobs.f90*
- 2m dewpoint
 - Modify new value at obs elevation by maintaining original obs dewpoint depression (T-Td)
- 10m wind (or other anemometer height above ground level (AGL))
 - Apply ob, as is, to be diagnosed 10m wind from model.
 - Need more general treatment in *getValues* to diagnose near-surface wind at x meters AGL, allowing for any anemometer height (AGL).
- Surface pressure – requires assumption about temperature of profile between model and surface Z.
- Coastline treatment – match land-use between model and obs (use surrounding model i/j points if needed)

Elevation correction

If $\text{abs}[\text{Psfc}(\text{obs}-\text{model})] < 70$ hPa.

Extrapolate obs from Psfc_{obs} to $\text{Psfc}_{\text{model}}$

Use model 1h low-level lapse rate.



Devenyi and Benjamin, 2003

Subsequent slides on other issues related to surface obs DA

- Option for pseudo-innovations in boundary layer
 - Benjamin et al 2016 MWR <https://doi.org/10.1175/MWR-D-15-0242.1>
 - Section 2.f
 - James and Benjamin 2017 MWR –
 - <https://doi.org/10.1175/MWR-D-16-0398.1>
 - Section 6
- Option for increased obs error as a function of elevation correction

Improved Forward Model for Surface Obs

Namelist	explanation	Default value	RAP value
dfi_radar_latent_heat_time_period	DFI forward integration window in minutes	30	30
metar_impact_radius	METAR cloud obs impact radius in grid number	10	10
metar_impact_radius_lowCloud	METAR low cloud observation impact radius in grid number	4	4
I_gsd_terrain_match_surfTobs	if .true., GSD terrain match for surface temperature observation	.false.	.true.
I_sfcobserror_ramp_t	namelist logical for adjusting surface temperature observation error	.false.	.true.
I_sfcobserror_ramp_q	namelist logical for adjusting surface moisture observation error	.false.	.true.
I_PBL_pseudo_SurfobsT	if .true. produce pseudo-obs in PBL layer based on surface obs T	.false.	.false.
I_PBL_pseudo_SurfobsQ	if .true. produce pseudo-obs in PBL layer based on surface obs Q	.false.	.true.
I_PBL_pseudo_SurfobsUV	if .true. produce pseudo-obs in PBL layer based on surface obs UV	.false.	.false
pblH_ration	percent of the PBL height within which to add pseudo-obs	0.75	0.75

GSI
namelist
options
developed
by GSD

Improved Forward Model for Surface Obs

Namelist	explanation	Default value	RAP value
dfi_radar_latent_heat_time_period	DFI forward integration window in minutes	30	30
metar_impact_radius	METAR cloud obs impact radius in grid number	10	10
metar_impact_radius_lowCloud	METAR low cloud observation impact radius in grid number	4	4
l_gsd_terrain_match_surfTobs	if .true., GSD terrain match for surface temperature observation	.false.	.true.
l_sfcobserror_ramp_t	namelist logical for temperature observation error	.false.	.true.
l_sfcobserror_ramp_q	namelist logical for observation error	.false.	.true.
l_PBL_pseudo_SurfobsT	if .true. produce pseudo-obs on surface obs T	.false.	.false.
l_PBL_pseudo_SurfobsQ	if .true. produce pseudo-obs on surface obs Q	.false.	.true.
l_PBL_pseudo_SurfobsUV	if .true. produce pseudo-obs on surface obs UV	.false.	.false.
pblH_ration	percent of the PBL pseudo-obs	0.75	0.75

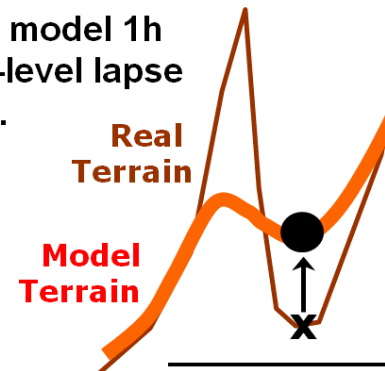
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Elevation correction

If $\text{abs}[\text{Psfc}(\text{obs}-\text{model})] < 70 \text{ hPa}$.

Extrapolate obs from Psfc_{obs} to $\text{Psfc}_{\text{model}}$

Use model 1h low-level lapse rate.



Improved Forward Model for Surface Obs


<code>I_use_2mQ4B</code>	if <code>.true.</code> use 2m Q/T as part of background to calculate surface Q observation innovation	<code>.false.</code>	<code>.true.</code>
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----- Z >>8m, k=1 level for NAM, GFS

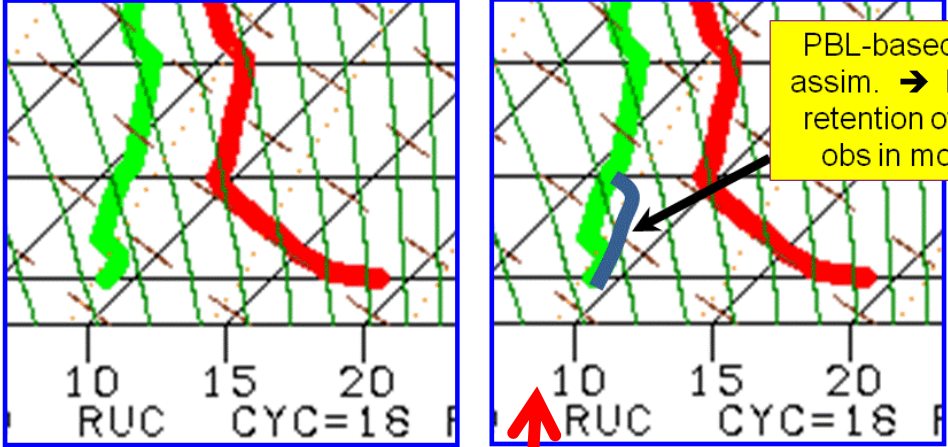
----- Z=8m, k=1 level for RAP ($\sigma=0.998$)

----- Z=2m, shelter height for temp/dewpoint obs

----- Z=0m, atmos/sfc interface



Improved Forward Model for Surface Obs

Namelist	explanation	Default value	RAP value
<div style="border: 2px solid red; padding: 5px;"> <p>PBL-based pseudo-observations</p>  </div>	flow in minutes	30	30
n	us in grid number	10	10
n	n impact radius in	4	4
l	r surface	.false.	.true.
l	surface	.false.	.true.
l	or	.false.	.true.
l	surface moisture	.false.	.true.
	observation error		
I_PBL_pseudo_SurfobsT	if .true. produce pseudo-obs in PBL layer based on surface obs T	.false.	.false.
I_PBL_pseudo_SurfobsQ	if .true. produce pseudo-obs in PBL layer based on surface obs Q	.false.	.true.
I_PBL_pseudo_SurfobsUV	if .true. produce pseudo-obs in PBL layer based on surface obs UV	.false.	.false
pblH_ratio	percent of the PBL height within which to add pseudo-obs	0.75	0.75

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