Updates to the Noah LSM in WRF Version 3.2

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Noah Land-Surface Model

- The Noah LSM is a collaboration among:
  - NCAR, NCEP, NASA, AFWA, Universities
    - UT-Austin, Purdue, University of Arizona ….
- The Urban Canopy Models are distinct from Noah, but coupled to WRF through the Noah LSM driver routine
    - CIEMAT, Spain; King's College, London; ….

Noah Physics Changes

- Snow changes:
  - Roughness length over snow modified to reflect the accumulation of snow burying surface features that contribute to roughness
    - Uses vegetation height as inferred from roughness length
  - User-tunable coefficient to the Livneh snow albedo scheme modifies the change to the albedo
    - Parameter set in GENPARM.TBL:
      - LVCOEF: Default value = 0.5
      - LVCOEF > 0.5 → Higher albedo values
      - LVCOEF < 0.5 → Lower albedo values

Noah-Related Changes

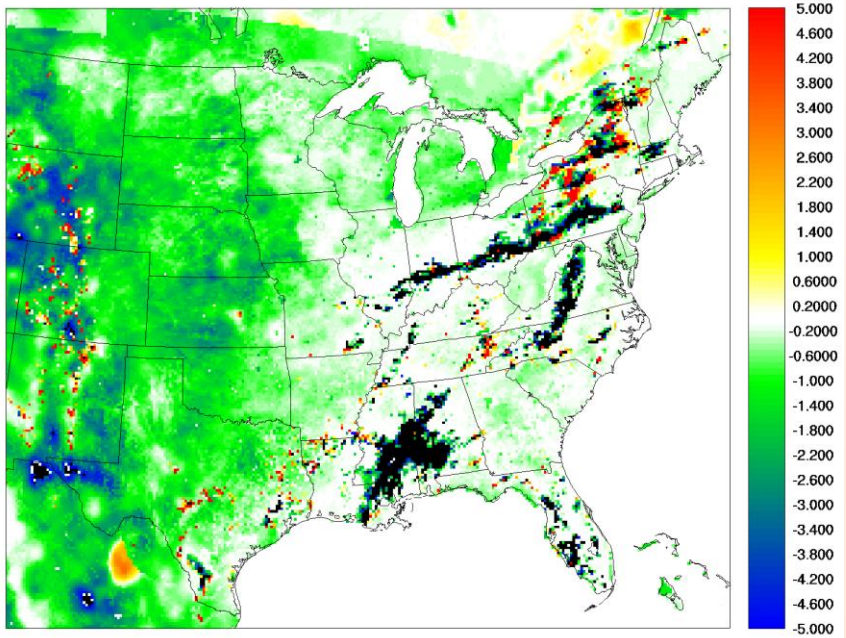
- CZIL option in MYJSFC and SFCLAY schemes:
  - Zilitinkivich coefficient, modifies coupling between surface and atmosphere
  - Observational studies show variation between about 0.01 and 1.0
  - Namelist option IZ0TLND
  - IZ0TLND = 0 for old behavior (CZIL=0.1)
  - IZ0TLND /= 0 for vegetation-dependent CZIL following Chen and Zhang 2009
- New Building Energy Model (BEM) is coupled Urban Canopy schemes

Noah Diagnostics Additions/Modifications

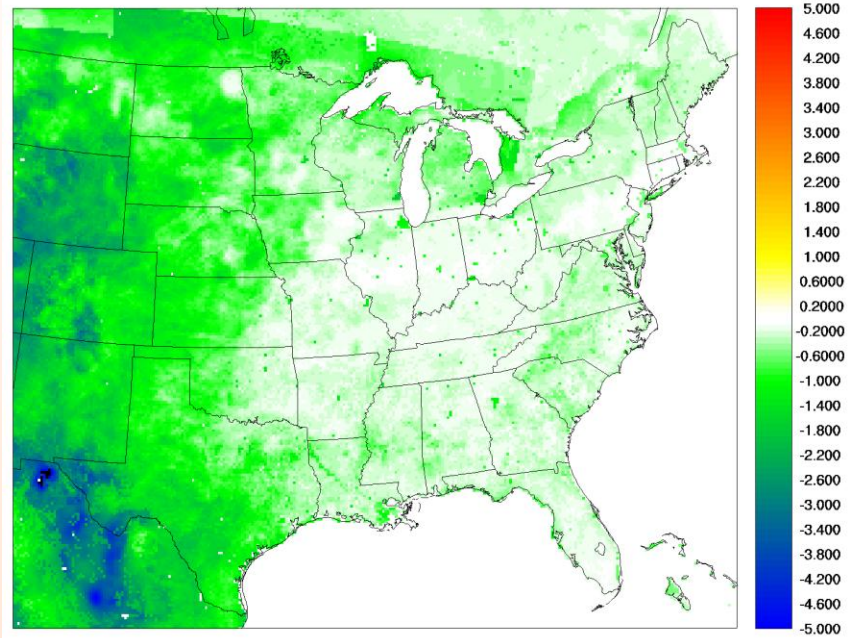
- Soil Moisture Availability computed and output
  - Output in WRF as "SMCREL: Relative Soil Moisture" at all levels
  - Fraction of soil moisture between wilting point SMCWLT (SMCREL=0.0) and saturation soil moisture SMCMAX (SMCREL=1.0)
- Surface Energy Budget Residual output
  - Surface energy budget terms had been computed, but not output
  - Energy budget residual now output as variable NOAHRES
  - An inconsistency in the budget calculations has been corrected
    - Heat flux from the change of temperature of falling precipitation had been considered in the Noah physics calculations, but not in the energy budget calculations
    - Correcting this eliminates large energy budget residuals seen during precipitation events

Energy Budget Residuals from offline (HRLDAS) Noah integration

Before fix:



After fix:



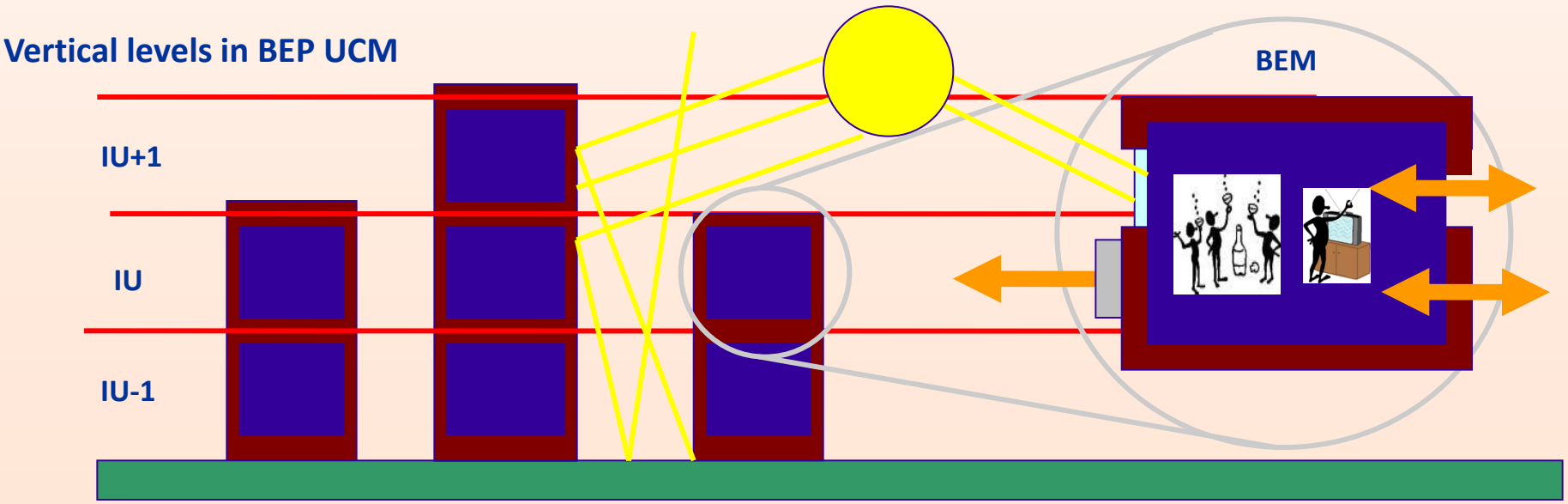
HRLDAS Energy Budget Residual

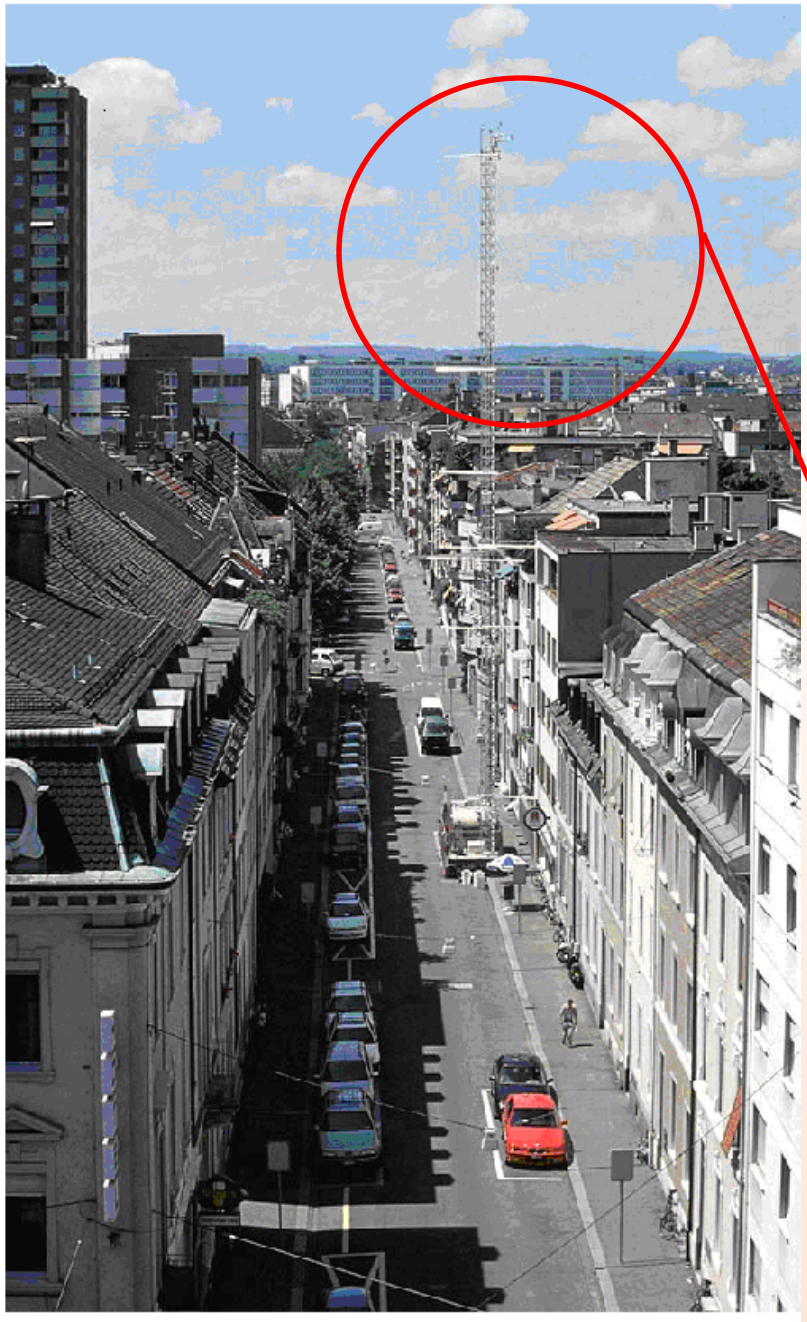
Reported problem: Cold bias

- Users moving from WRF Version 3.0.1 to Version 3.1 have reported a cold bias
  - NCAR is investigating – ongoing work
- There seem to be multiple sources:
  - RRTM fix to ozone profile in 3.1
    - small effect, but it does make things colder
  - Snow albedo table changes (VEGPARM.TBL) in 3.1
  - Seasonal variation in 3.1 of parameters between maximum and minimum values in VEGPARM.TBL
    - Variation of albedo does make things cooler
    - Variation of leaf-area index (LAI)
      - Makes things different – unclear as yet whether this is a consistently colder trend

New Building Energy Model (BEM) coupled with Multi-Layer Urban Canopy Model (BEP)

- BEM is a simple box type heat budget model in which a building in an urban block is treated as a pile of boxes
- The time evolutions of the floor air temperature and air humidity are estimated separately. The natural ventilation, the heat generated by equipment and occupants, the convective heat through the walls, and the radiation through the windows are considered in the model.
- The heat needed for cooling/heating the indoor air temperature can be computed considering an air conditioning (AC) system.

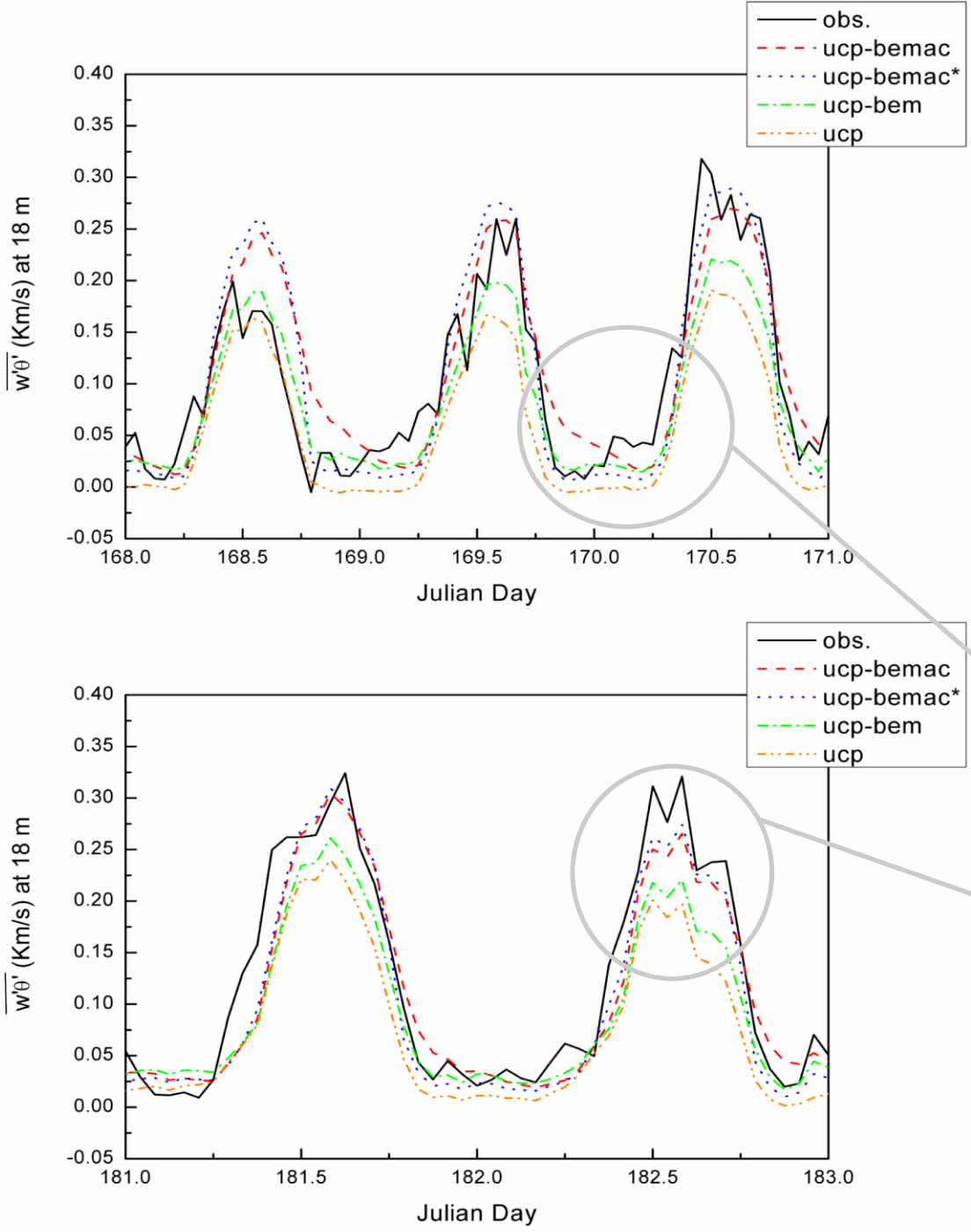




Offline Tests (1D)

- The UCP(BEP) and BEP-BEM (with and without the AC systems) schemes have been evaluated against urban energy balances fluxes measured in the BUBBLE experiment.
- The measurement set up consisted of a tower inside a street canyon that reaches up to ≈ 2.2 times (32m) the mean roof height of the urban site.
- Measurements were taken at different heights in and above the street canyon with a 10-min average time resolution.
- Sensors of temperature were installed inside some buildings where the AC systems were working.

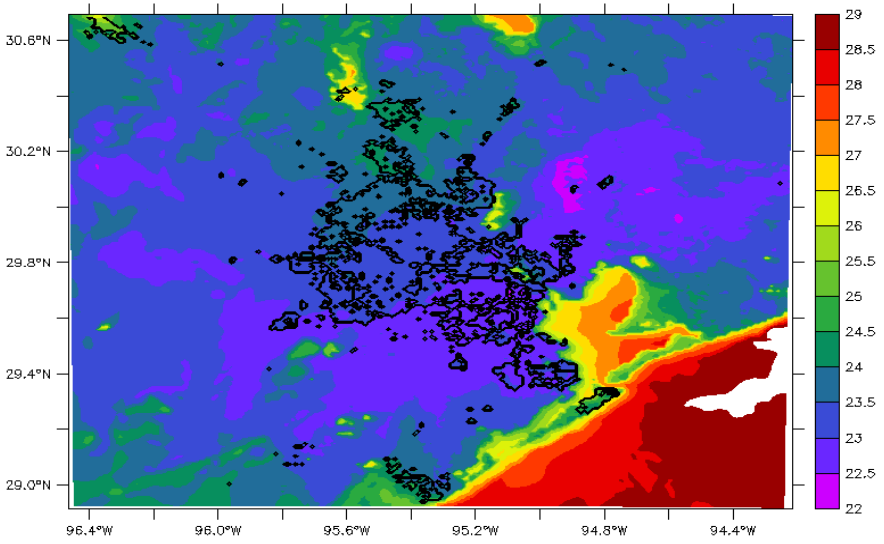
Results



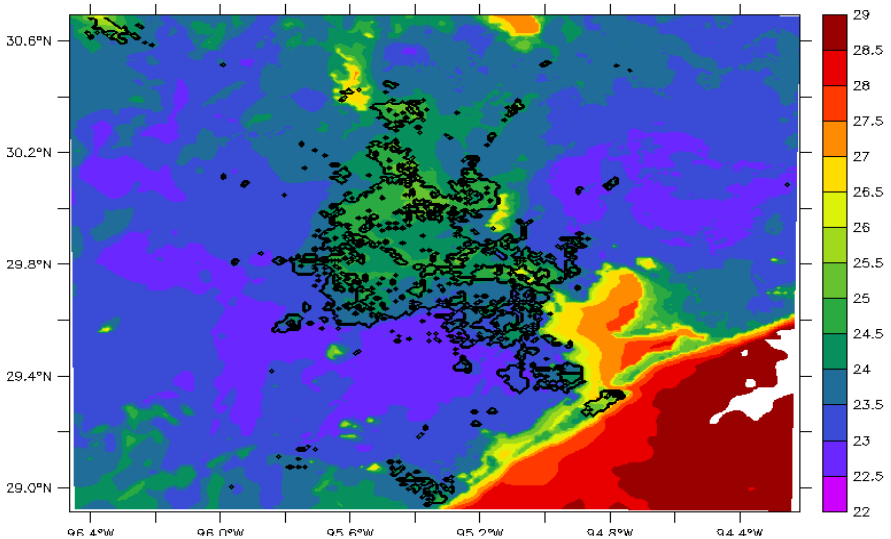
- Kinematic heat fluxes computed in four different simulations against measurements at 18m above ground. Only three selected days for the first period (from 165 to 174), and two selected days for the second (from 181 to 195) are shown.
- During the night the UCP-BEM parameterization fits better than the old UCP scheme.
- During the day only the UCP-BEMAC (BEM with Air Conditioning effects) schemes are able to satisfactorily reproduce the observed values.

Urban Heat Island: 2 m air temperature (ºC)

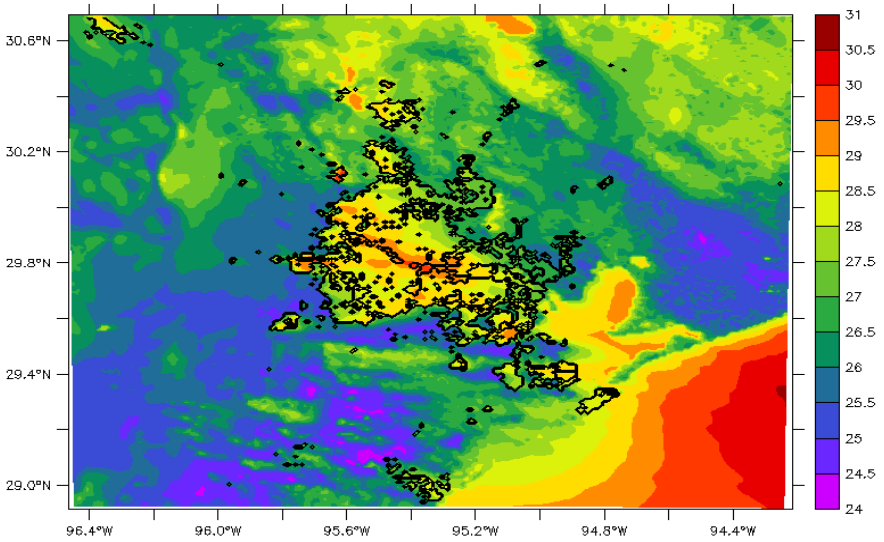
a) BEP 26th August 2000



b) BEP + BEM 26th August 2000

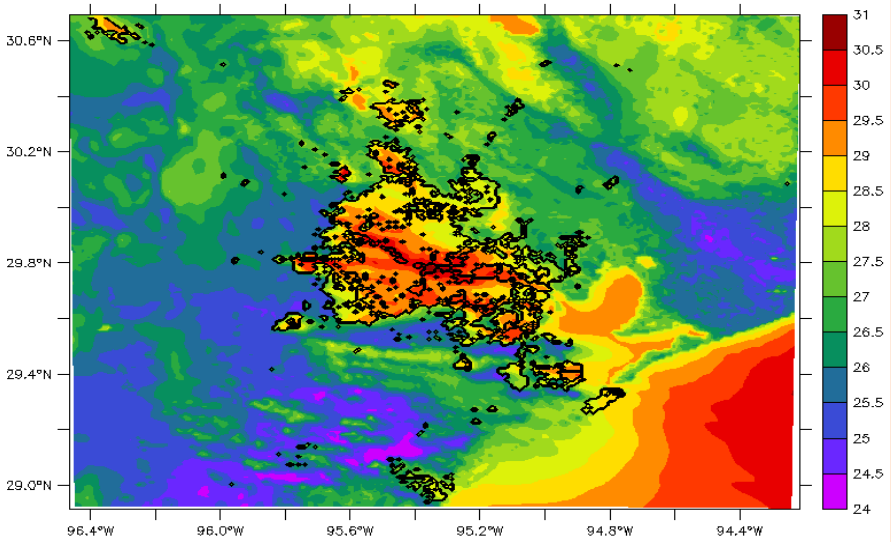


c) BEP 01st September 2000



T2 at 0300 LST obtained with the BEP scheme

d) BEP + BEM 01st September 2000



T2 at 0300 LST obtained with the BEP+BEM scheme

A note regarding the Single-Layer Urban Canopy Model (SF_URBAN_PHYSICS=1)

- In the WRF 3.2 release, the default URBPARM.TBL contains unrealistic values for certain urban parameters
  - The effect of these unrealistic values is:
    - Reduced nighttime Urban Heat Island effect
    - Low sensible heat flux
- URBPARM.TBL will be corrected in an upcoming WRF 3.2.1 release
- In the meantime, users of the single-Layer Urban Canopy Model are advised to use values from the 3.1 release, if they have not already adjusted the table values to better fit their cities' morphology

Parameter	Cat 1	Cat 2	Cat 3	Cat 1	Cat 2	Cat 3
ZR	10.0	7.5	5.0	8.9	5.1	5.4
ROOF_WIDTH	10.0	9.4	8.3	31.7	25.7	17.6
ROAD_WIDTH	10.0	9.4	8.3	98.9	39.2	108.0
FRC_URB	0.95	0.9	0.5	0.865	0.429	0.429
	3.1 values (preferred)			3.2 values (wrong)		

Thank You

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