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WRF-Sfire in ideal cases

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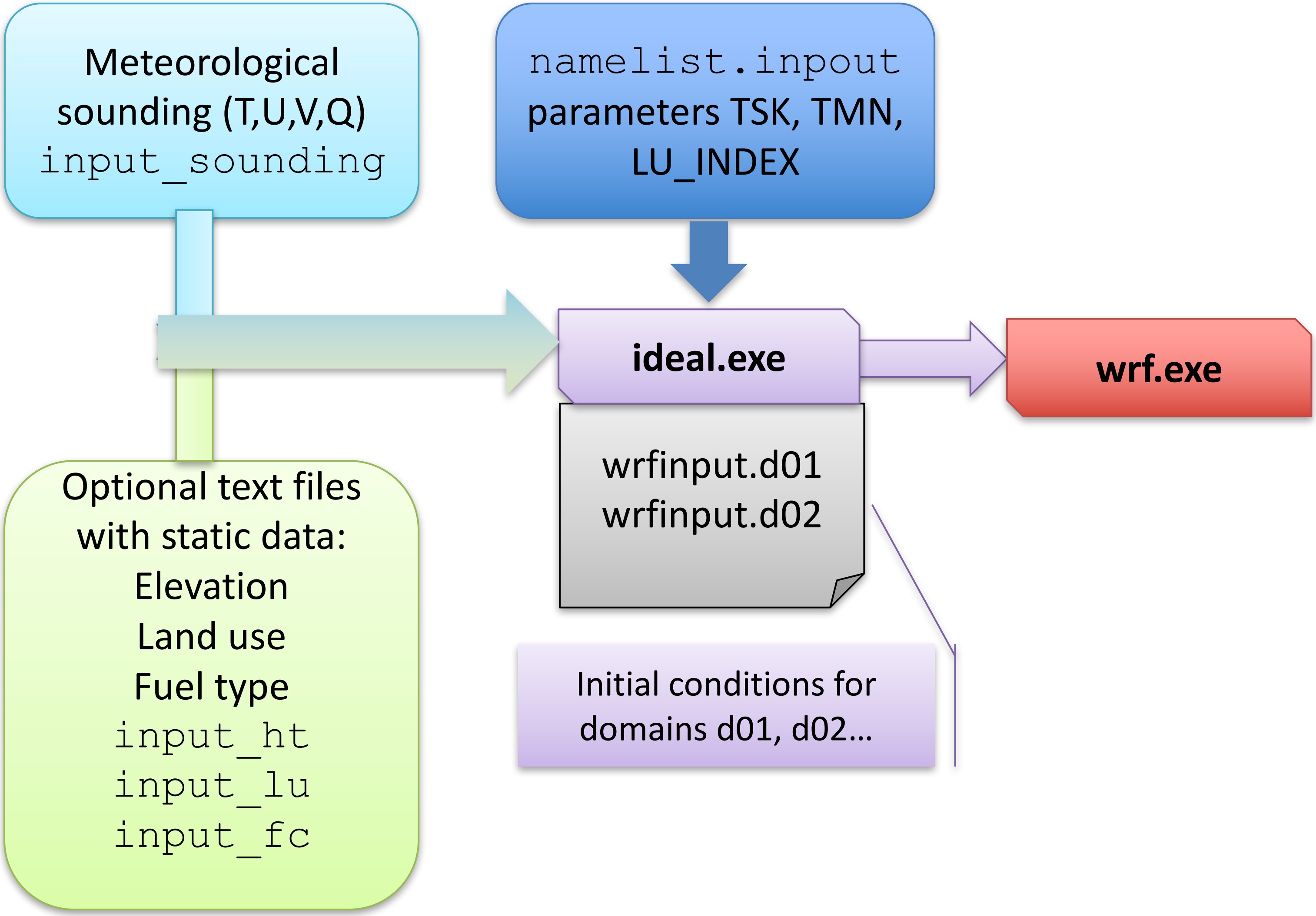
WRF Structure for ideal cases



Meteorological sounding (T,U,V,Q)
`input_sounding`

`namelist.inpout`
parameters TSK, TMN, LU_INDEX

ideal.exe

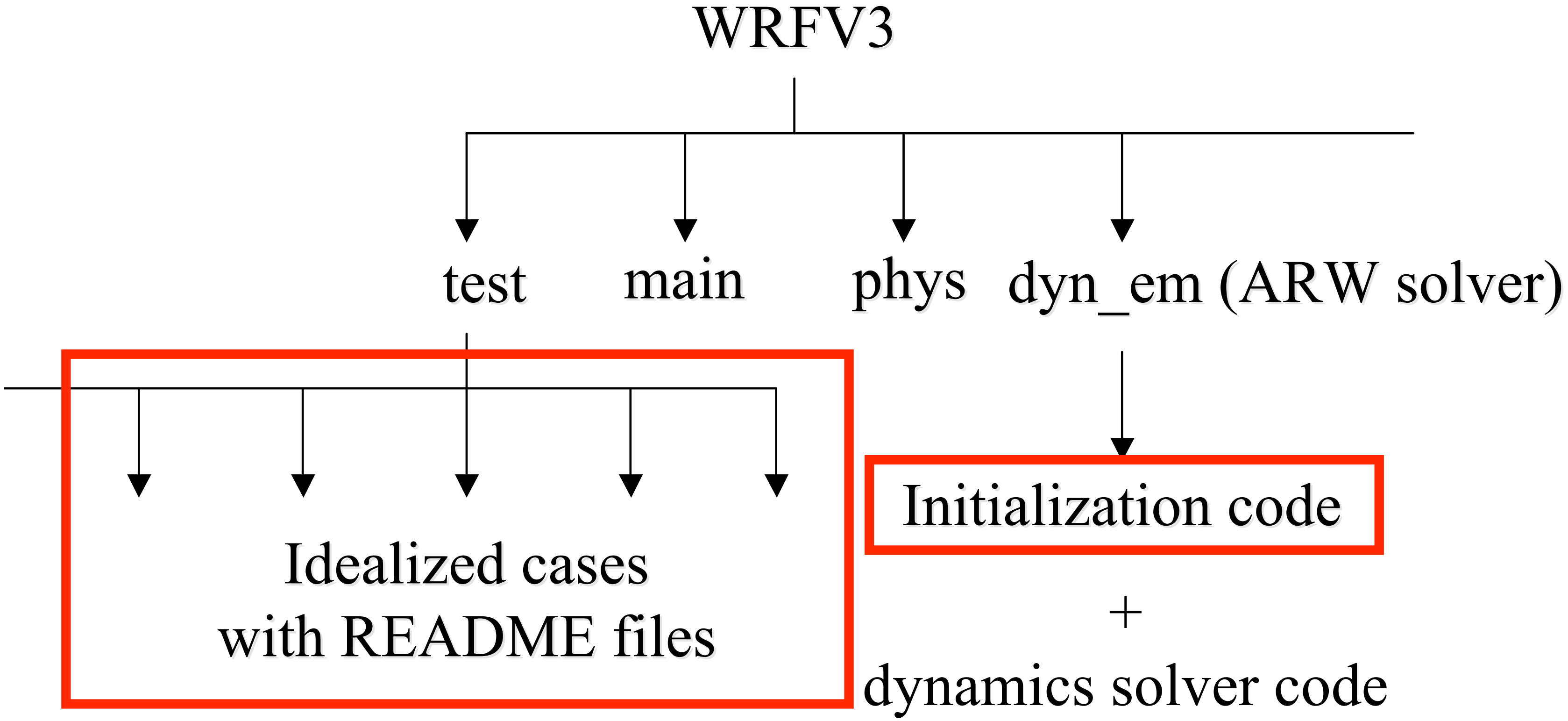
wrf.exe

wrfinput.d01
wrfinput.d02

Initial conditions for domains d01, d02…

Optional text files with static data:
Elevation
Land use
Fuel type
`input_ht`
`input_lu`
`input_fc`

WRF Structure for idealized cases



WRFV3

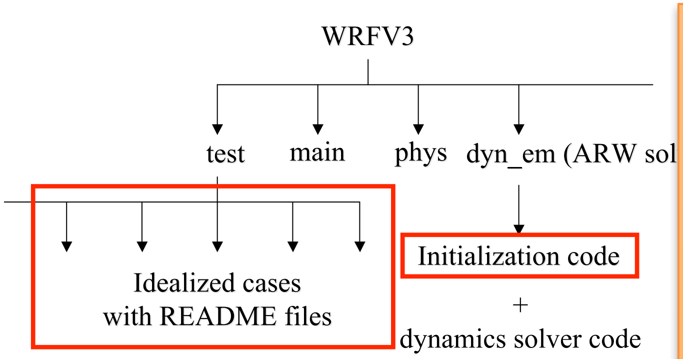
test main phys dyn_em (ARW solver)

Idealized cases
with README files

Initialization code
+
dynamics solver code

- em_b_wave
- em_esmf_exp
- **em_fire**
- em_grav2d_x
- em_heldsuarez
- em_hill2d_x
- em_les
- em_quarter_ss
- em_real
- em_scm_xy
- em_seabreeze2d_x
- em_squall2d_x
- em_squall2d_y
- em_tropical_cyclone
- exp_real
- nmm_real

WRF Structure for idealized cases



Idealized cases in:
WRFV3/dyn_em/
module_init_utilities.F
module_initialize_fire.F
Module_initialize…

IDEAL
WRFV3/test/em_fire/
chem
fireflux_small
heatflux_2d
heatflux_ronan
hill
hill_coarse
hill_med
hill_simple
moisture
nested
rain
small
[…]

namelist.input
input_sounding
Input_lu
Input_ht
Input_fc

wrfinput.d01
wrfinput.d02

wrflow.d01
wrflow.d02
….
wrfbdy.d01

ideal.exe DOES NOT generate boundary condition files. Generally, one of the idealized boundary conditions provided by WRF (open, cyclic, symmetric) should be used in ideal cases

Input_sounding file structure

surface Pressure (mb)

surface potential Temperature (K)

Surface vapor mixing ratio (g/kg)

line 1

```
1000.00     300.00     14.00
  250.00     300.45     14.00      -7.88      -3.58
  750.00     301.25     14.00      -6.94      -0.89
 1250.00     302.47     13.50      -5.17       1.33
 1750.00     303.93     11.10      -2.76       2.84
 2250.00     305.31      9.06       0.01       3.47
 2750.00     306.81      7.36       2.87       3.49
 3250.00     308.46      5.95       5.73       3.49
 3750.00     310.03      4.78       8.58       3.49
 4250.00     311.74      3.82      11.44       3.49
 4750.00     313.48      3.01      14.30       3.49
```

each successive line is a point in the sounding

Height (m)

Potential temperature (K)

Water vapor Mixing ratio (g/kg)

U wind speed (m/s)

V wind speed (m/s)

Input files structure

In order to allow users to easily create more realistic yet simple cases the model can ingest additional surface data from external ASCII files:

input_ht - allows the user to define custom topography in an ideal case
input_lu – allows the user to add a custom land use in an ideal case
input_fc – allows the user to add a custom fuel map in an ideal case

How to generate the input_XX files?
`wrf-fire/other/Matlab/util1_jan/write_array_2d.m`

Other useful matlab tools:

```
read_array_2d.m
image_array_2d.m
...
```

namelist.input

```
&time_control
 run_days                            = 0,
 run_hours                           = 0,
 run_minutes                         = 20,
 run_seconds                         = 0,
 start_year                          = 2006, 0001, 0001,
 start_month                         = 02,   01,   01,
 start_day                           = 23,   01,   01,
 start_hour                          = 12,   00,   00,
 start_minute                        = 43,   01,   01,
 start_second                        = 00,   00,   00,
 end_year                            = 2006, 0001, 0001,
 end_month                           = 02,   01,   01,
 end_day                             = 23,   01,   01,
 end_hour                            = 13,   00,   00,
 end_minute                          = 00,   600,   600,
 end_second                          = 0,   00,   00,
 history_interval_s                  = 5,   30,   30,
 frames_per_outfile                  = 1000, 1000, 1000,
 restart                             = .false.,
 restart_interval                    = 5
 io_form_history                     = 2
 io_form_restart                     = 2
 io_form_input                       = 2
 io_form_boundary                    = 2
 debug_level                         = 1
/
```

↑ ↑ ↑

d01 d02 d03

namelist.input

```
&domains
 time_step                           = 0,
 time_step_fract_num                 = 3,
 time_step_fract_den                 = 10,
 max_dom                             = 1,
 s_we                                = 1,     1,     1,
 e_we                                = 20,    43,    43,
 s_sn                                = 1,     1,     1,
 e_sn                                = 32,    43,    43,
 s_vert                              = 1,     1,     1,
 e_vert                              = 41,    41,    41,
 dx                                  = 50,    30,    10,
 dy                                  = 50,    30,    10,
 ztop                                = 600, 1500, 1500,
 grid_id                             = 1,     2,     3,
 parent_id                           = 0,     1,     2,
 i_parent_start                      = 0,     1,    1,
 j_parent_start                      = 0,     1,    1,
 parent_grid_ratio                   = 1,     2,     3,
 parent_time_step_ratio              = 1,     2,     3,
 feedback                            = 1,
 smooth_option                       = 0
 sr_x                                = 10,     0,      0
 sr_y                                = 10,     0,      0
/
```

namelist.input

```
&physics
 mp_physics                          = 0,     0,     0,
 ra_lw_physics                       = 0,     0,     0,
 ra_sw_physics                       = 0,     0,     0,
 radt                                = 30,    30,    30,
 sf_sfclay_physics                   = 1,     0,     0,
 sf_surface_physics                  = 1,     0,     0,
 bl_pbl_physics                      = 0,     0,     0,
 bldt                                = 0,     0,     0,
 cu_physics                          = 0,     0,     0,
 cudt                                = 0,     0,     0,
 isfflx                              = 1,
 ifsnow                              = 0,
 icloud                              = 0,
 num_soil_layers                     = 5,
 mp_zero_out                         = 0,
 /
```

namelist.input

```
&dynamics
 rk_ord                              = 3,
 diff_opt                            = 2,
 km_opt                              = 2,
 damp_opt                            = 2 ,
 zdamp                               = 100.,  5000.,  5000.,
 dampcoef                            = 0.2,    0.2,    0.2
 khdif                               = 0.05,   0.05,   0.05,
 kvdif                               = 0.05,   0.05,   0.05,
 smdiv                               = 0.1,    0.1,    0.1,
 emdiv                               = 0.01,   0.01,   0.01,
 epssm                               = 0.1,    0.1,    0.1
 mix_full_fields                     = .true., .true., .true.,
 non_hydrostatic                     = .true., .true., .true.,
 h_mom_adv_order                     = 5,      5,      5,
 v_mom_adv_order                     = 3,      3,      3,
 h_sca_adv_order                     = 5,      5,      5,
 v_sca_adv_order                     = 3,      3,      3,
 time_step_sound                     = 20,     20,     20,
 moist_adv_opt                       = 1,      1,      1,
 scalar_adv_opt                      = 1,      1,      1,
 tracer_opt                          = 2,      2,      2,
 /
```

namelist.input

```
&bdy_control
periodic_x                          = .false.,.false.,.false.,
symmetric_xs                        = .false.,.false.,.false.,
symmetric_xe                        = .false.,.false.,.false.,
open_xs                             = .true., .false.,.false.,
open_xe                             = .true., .false.,.false.,
periodic_y                          = .false.,.false.,.false.,
symmetric_ys                        = .false.,.false.,.false.,
symmetric_ye                        = .false.,.false.,.false.,
open_ys                             = .true., .false.,.false.,
open_ye                             = .true., .false.,.false.,
nested                              = .false., .true., .true.,
/
```

namelist.input

```
 &fire
 ifire                 = 2,    ! integer, = 0: no fire, 2=turn on fire model
 fire_fuel_read        = 2,    ! integer, -1: from WPS, 0= use fire_fuel_cat, 1= by altitude,
2=from file input_fc
 fire_fuel_cat         = 3,    ! integer, fuel category if constant
! ignition
 fire_num_ignitions = 2,        ! integer, only the first fire_num_ignition used, up to 5
allowed
 fire_ignition_ros1 =   0.05,  ! start points of ignition lines, in m from lower left corner
 fire_ignition_start_x1 =  475,  ! start points of ignition lines, in m from lower left corner
 fire_ignition_start_y1 = 1075,  ! start points of ignition lines, in m from lower left corner
 fire_ignition_end_x1 =    305,  ! end points of ignition lines, in m from lower left corner
 fire_ignition_end_y1 =   1075,  ! end points of ignition lines, in m from lower left corner
 fire_ignition_radius1 =    20,  ! all within this radius will ignite, > fire mesh step
 fire_ignition_start_time1 = 30,  ! sec for ignition from the start
 fire_ignition_end_time1  = 184,  ! sec for ignition from the start
 fire_ignition_ros2 =   0.05,  ! start points of ignition lines, in m from lower left corner
 fire_ignition_start_x2 =  475,  ! start points of ignition lines, in m from lower left corner
 fire_ignition_start_y2 = 1075,  ! start points of ignition lines, in m from lower left corner
 fire_ignition_end_x2 =    690,  ! end points of ignition lines, in m from lower left corner
 fire_ignition_end_y2 =   1075,  ! end points of ignition lines, in m from lower left corner
 fire_ignition_radius2 =    20,  ! all within this radius will ignite, > fire mesh step
 fire_ignition_start_time2 = 30,  ! sec for ignition from the start! end ignition for sfire
 fire_ignition_end_time2  = 194,  ! sec for ignition from the start! end ignition for sfire
```

namelist.input

```
 fire_mountain_type=0,           ! in ideal: 0=none, 1= hill, 2=EW ridge, 3=NS ridge
 fire_mountain_height=500.,      ! (m) ideal mountain height
 fire_mountain_start_x=1000.,    ! (m) coord of start of the mountain from lower left corder
(just like ignition)
 fire_mountain_start_y=1100.,    ! (m) coord of start of the mountain from lower left corder
(just like ignition)
 fire_mountain_end_x=1500.,      ! (m) coord of end of the mountain from lower left corder (just
like ignition)
 fire_mountain_end_y=1400.,      ! (m) coord of end of the mountain from lower left corder (just
like ignition)
 fire_topo_from_atm=1,           ! 0 = fire mesh topo set from fine-res data, 1 = populate by
interpolating from atmosphere
 delt_perturbation = 0.0,        ! Temperature perturbation for creating cold (negative) / warm
(positive) bubble [K], 0 turns it off
 !xrad_perturbation = 10000.0,    ! Horizontal radius of the bubble in E-W direction [m]
 !yrad_perturbation = 10000.0,    ! Horizontal radius of the bubble in N-S direction [m]
 !zrad_perturbation = 1500.0,     ! Vertical radius of the bubble [m]
 !hght_perturbation = 1500.0,     ! Perturbation height - height at which the warm/cold bubble
will be suspended [m]
!
!
```

namelist.input

```
! stretched grid variables
!
 stretch_grd = .true.,
 stretch_hyp = .true.,
 z_grd_scale = 2.35
!
! Surface initialization
!
 sfc_full_init =.true.
 sfc_lu_index = 28,             ! Defines USGS surface category used for surface initialization
based on LANDUSE.TBL (roughness, albedo etc)
 sfc_tsk = 285.0,                ! Skin surface temperature [K]
 sfc_tmn = 280.0,                ! Mean soil temperature [K]
! sfc_ivgtyp = 18,                ! Dominant vegetation category, needed only with Noah LSM
(sf_surface_physics=2)
! sfc_isltyp = 7,                 ! Dominant soil type, needed only with Noah LSM
(sf_surface_physics=2)
! sfc_canwat = 0.2,               ! Canopy water content, needed only with Noah LSM
(sf_surface_physics=2)
! sfc_vegfra = 0.5,               ! Vegetation fraction, needed only with Noah LSM
(sf_surface_physics=2)
!
! files
fire_read_atm_ht = .false.,      ! read terrain height from file ht_input
fire_read_lu = .true.,          ! read land use data from input_lu file
```

namelist.fire

```
&fuel_scalars                       ! scalar fuel constants
cmbcnst  = 17.433e+06,              ! J/kg combustion heat dry fuel
hfgl     = 17.e4 ,                  ! W/m^2 heat flux to ignite canopy
fuelmc_g = 0.18,                    ! ground fuel moisture, set = 0 for dry
!jc fuelmc_g = 0.09,                    ! ground fuel moisture, set = 0 for dry
fuelmc_c = 1.00,                    ! canopy fuel moisture, set = 0 for dry
nfuelcats = 13,                     ! number of fuel categories used
no_fuel_cat = 14                    ! extra category for no fuel
/

&fuel_categories
 fuel_name =
'1: Short grass (1 ft)',
'2: Timber (grass and understory)',
'3: Tall grass (2.5 ft)',
'4: Chaparral (6 ft)',
'5: Brush (2 ft) ',
'6: Dormant brush, hardwood slash',
'7: Southern rough',
'8: Closed timber litter',
'9: Hardwood litter',
'10: Timber (litter + understory)',
'11: Light logging slash',
'12: Medium logging slash',
'13: Heavy logging slash',
'14: no fuel'
```

namelist.fire

Fuel category 1 2 3 4 5 6 7

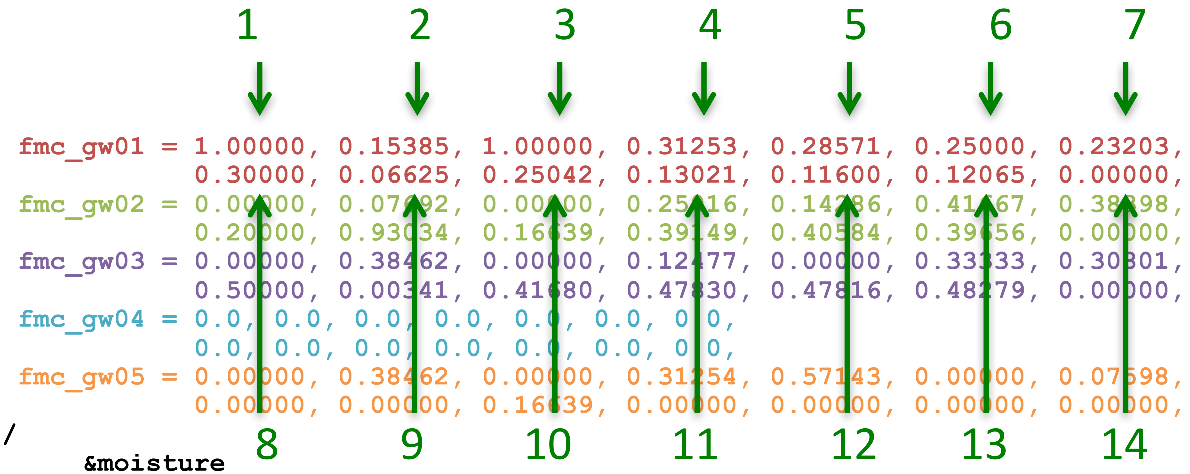
```
windrf= 0.36, 0.36, 0.44,  0.55,  0.42,  0.44,  0.44,
        0.36, 0.36, 0.36,  0.36,  0.43,  0.46, 1e-7
```

8 9 10 11 12 13 14

```
fgi =  0.166, 0.897, 1.08, 2.468, 0.785, 1.345, 1.092,          ! Initial total mass of
    1.121, 0.780, 2.694, 2.582, 7.749, 13.024, 1.e-7,          ! surface fuel (kg/m^2)
fueldepthm=0.305, 0.305, 1.5, 1.829, 0.61,  0.762, 0.762,
           0.061, 0.061, 0.305, 0.305, 0.701, 0.914, 0.305,    !Fuel depth (m)
savr = 3500., 2784., 1500., 1739., 1683., 1564., 1562.,        !Surface area to volume ratio
       1889., 2484., 1764., 1182., 1145., 1159., 3500.,
fuelmce = 0.12, 0.15, 0.25, 0.20, 0.20, 0.25, 0.40,            !Fuel moisture of extinction
          0.30, 0.25, 0.25, 0.15, 0.20, 0.25, 0.12,
fueldens = 32.,32.,32.,32.,32.,32.,32. ,
           32.,32.,32.,32.,32.,32.,32. ,                       ! Particle Density
st = 0.0555, 0.0555, 0.0555, 0.0555, 0.0555, 0.0555, 0.0555,    ! Fuel particle total mineral
     0.0555, 0.0555, 0.0555, 0.0555, 0.0555, 0.0555, 0.0555,    ! content
se = 0.010, 0.010, 0.010, 0.010, 0.010, 0.010, 0.010,           ! Effective mineral content
```

namelist.fire

Fuel moisture contribution per fuel category



```
fmc_gw01 = 1.00000, 0.15385, 1.00000, 0.31253, 0.28571, 0.25000, 0.23203,
           0.30000, 0.06625, 0.25042, 0.13021, 0.11600, 0.12065, 0.00000,
fmc_gw02 = 0.00000, 0.07692, 0.00000, 0.25016, 0.14286, 0.41667, 0.38398,
           0.20000, 0.93034, 0.16639, 0.39149, 0.40584, 0.39656, 0.00000,
fmc_gw03 = 0.00000, 0.38462, 0.00000, 0.12477, 0.00000, 0.33333, 0.30801,
           0.50000, 0.00341, 0.41680, 0.47830, 0.47816, 0.48279, 0.00000,
fmc_gw04 = 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
           0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
fmc_gw05 = 0.00000, 0.38462, 0.00000, 0.31254, 0.57143, 0.00000, 0.07598,
           0.00000, 0.00000, 0.16639, 0.00000, 0.00000, 0.00000, 0.00000,
/
     &moisture
     moisture_class_name =
     '1 hour fuel',
     '10 hour fuel',
     '100 hour fuel',
     '1000 hour fuel',
     'live fuel'

moisture_classes=         5,                  ! number of classes, max 5 (see comments in module_fr_sfire_phys.F how
to increase)
drying_model=             1,     1,     1,     1,     1, ! number of model - only 1= equilibrium moisture Van
Wagner (1972) per Viney (1991)  allowed
drying_lag=               1,    10,   100,  1000,   1e9,! so-called 10hr and 100hr fuel
wetting_model=            1,     1,     1,     1,     1, ! number of model - only 1= allowed at this moment
wetting_lag=             14,   1e9,   1e9,   1e9,   1e9, !
saturation_moisture=    2.5,   2.5,   2.5,   2.5,   2.5, ! ditto
saturation_rain =       8.0,   8.0,   8.0,   8.0,   8.0, ! stronger rain than this (mm/h) does not make much
difference.
rain_threshold =       0.05,  0.05,  0.05,  0.05,  0.05,! mm/h rain too weak to wet anything.
fmc_gc_initialization =   2,     2,     2,     2,     2,! 0 = from input, 1 = from fuelmc_g in namelist.input 2 =
from equibrium
/
```

WRF output

WRF generates files in the netcdf format
They can be accessed by any visualization package with the nectdf support:

- Ncview
- Ncbrowser
- NCL
- Matlab
- Vapor
- etc…

Experiments

Ideal cases:

Experiment1. Flat simple, uniform fuel, idealized

Experiment2. Idealized with additional features - topography, smoke

HGT, tr17_1, no LU_INDEX, no T2 no TSLB

Experiment3. Flat uniform fuel and initialized surface, everything from namelists

we have T2, LU_INDEX, U*, TSLB,

Experiment4. Flat (no topo), heterogeneous fuel and surface, (idealized FireFlux):

Prescribed LU, prescribed TSK, see T2 and LU effects on U*.

Data comes form external text files:

`input_fc`	`fire_fuel_read / fire_fuel_cat`
`input_ht`	`fire_read_atm_ht`
`input_lu`	`fire_read_lu`
`input_zsf`	`fire_read_fire_ht`

Experiments

Experiment 5.

Actual terrain, prescribed fuel, prescribed landuse (LU):

source data in ./matlabfiles/

matlab files: HGT.mat -> input_ht
LU_INDEX.mat -> input_lu
ZSF.mat -> input_zsf
NFUEL_CAT.mat -> input_fc
HGT_V(121,:)=HGT_V(120,:); fix HGT

`input_fc`	`fire_fuel_read / fire_fuel_cat`
`input_ht`	`fire_read_atm_ht`
`input_lu`	`fire_read_lu`
`input_zsf`	`fire_read_fire_ht`

Tools:

- wrf-fire/other/Matlab/util1_jan/write_array_2d.m
- wrf-fire/other/Matlab/util1_jan/read_array_2d.m

- special flags to use external files for idealized cases

```
fire_read_atm_ht= .true.,   ! read terrain height from file input_ht
fire_red_fire_ht=.true.      ! read terrain height from file input_zsf
fire_read_lu = .true.,       ! read land use data from input_lu file
fire_fuel_read     = 2,      ! integer, -1: from WPS, 0= use
fire_fuel_cat, 2=from file input_fc
```

How to set up and run WRF?

1. Install git to be able to download git repositories
2. Get the code from openwfm git repository:
   ```
   git clone git://github.com/jbeezley/wrf-fire.git
   ```
3. Install netcdf and fortran compiler in macports it will be:
   ```
   sudo port install netcdf-fortran
   ```
4. Set up your environment
   ```
   export NETCDF=/opt/local
   ```
5. Configure the model:
   ```
   /WRFV3/configure
   ```
6. Compile the model
   ```
   /WRFV3/compile em_fire >& compile.log&
   ```
7. Compile the preprocessing system WPS
   ```
   /WPS/compile >& compile.log&
   ```
8. Set up the model parameters in namelist.input and namelist.fire
9. Create wrfinput files (initialization): go to a selected case in /WRFV3/test/em_fire/ and run
   ```
   /WRFV3/test/em_fire/your_case/ideal.exe
   ```
   – it will create wrfinput_d01 file.
10. Run the model
    ```
    /WRFV3/test/your_case/wrf.exe
    ```