A HIGH-RESOLUTION LAND DRYNESS ANALYSIS SYSTEM FOR AUSTRALIA

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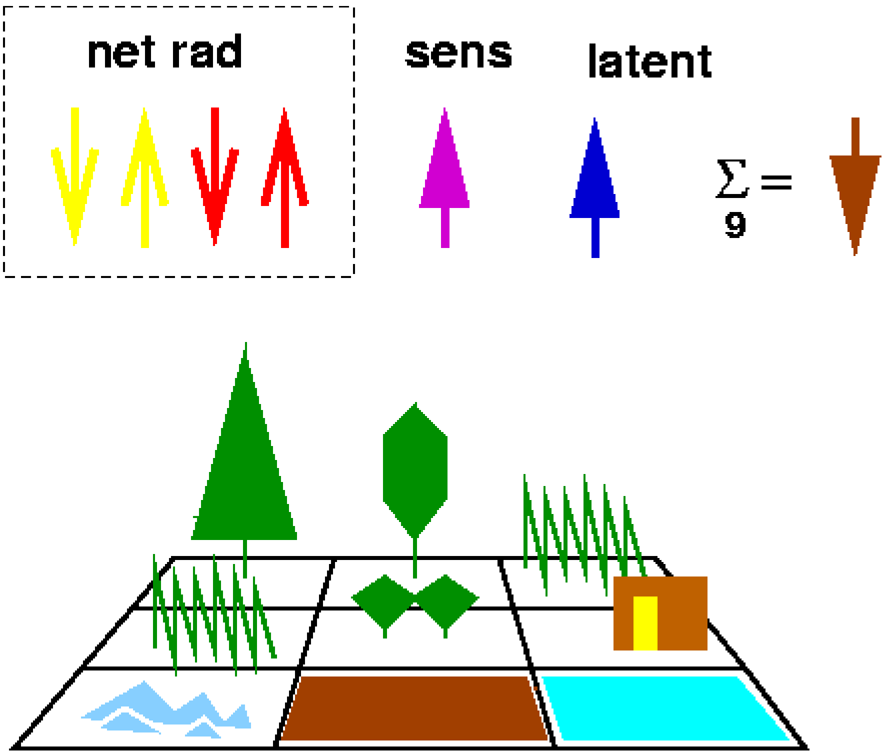
ABSTRACT

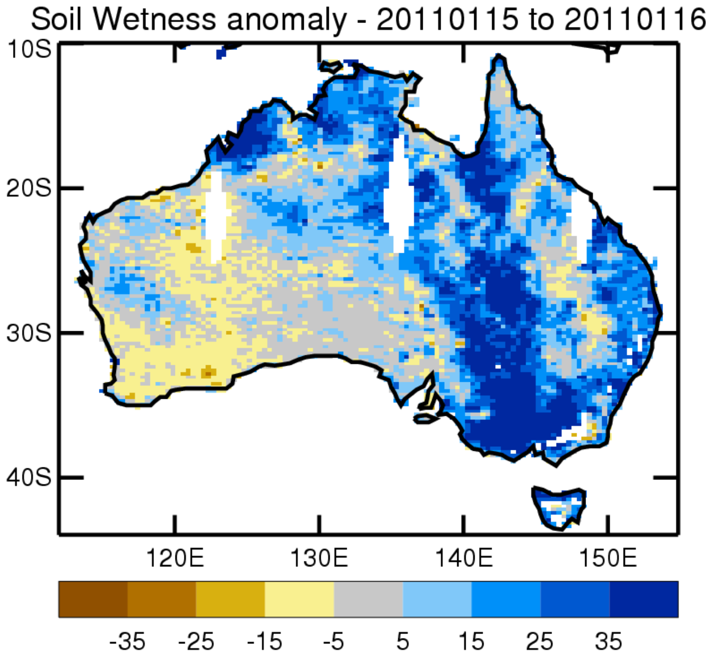
Good estimates of landscape dryness underpin fire danger rating, fire behaviour models, flood prediction, and landslip warning. Soil dryness also strongly influences heatwave development by driving the transfer of solar heating from the soil surface into air temperature rise. Currently landscape dryness, for fire danger prediction, is estimated using very crude models developed in the 1960s that do not take into account different soil types, slope, aspect and many other factors. This work presents a high-resolution soil dryness analysis system that includes data from many sources; such as surface observations of rainfall, temperature, dew-point temperature, wind speed, surface pressure, as well as satellite-derived measurements of rainfall, surface soil moisture, downward surface shortwave radiation, skin temperature, leaf area index and tree heights. The analysis system estimates soil dryness on four soil layers over the top three metres of soil, the surface layer has a thickness of 10cm. The system takes into account the effect of different vegetation types, root depth, stomatal resistance and spatially varying soil texture. The analysis system has a one hour time-step with daily updating. Data assimilation methods are used to extract the maximum amount of useful information from the observations and model. The only practical way to observe the land surface on a national scale is through satellite remote sensing. Unfortunately, such satellite data is prone to biases and corruption. Therefore, it is essential to apply quality control and bias correction. In addition, satellite measurements are infrequent with repeat times of about one day and contain gaps. Data assimilation can filter the random errors from the satellite measurements and fill in both the spatial and temporal gaps in the measurements. Verification against ground-based soil moisture observations from the OzNet, CosmOz and OzFlux networks shows that the new system is significantly more accurate than the traditional soil dryness indices.

PHYSICALLY BASED LAND SURFACE MODEL



Modern land models calculate landscape dryness with greater sophistication and account for details such as soil texture, solar insolation, root depth, vegetation type and stomatal resistance. The Australian Community Climate and Earth System Simulator model has four soil layers. The topmost layer from the surface to 10cm is critical for the exchange of moisture between the soil and forest litter fuels. The lowest layer extends down to three metres.

SATELLITE DATA



There are few ground-based observations of soil moisture and temperature. However, a number of new satellite systems have been launched that can provide information about surface soil moisture, soil temperature and vegetation properties such as leaf area index. The advantage of these satellite systems is that they provide national coverage on a daily timescale. Advanced land data assimilation schemes can be used to blend the satellite measurements with model forecasts.

LAND SURFACE DATA ASSIMILATION

Data assimilation is the process through which the maximum amount of useful information can be extracted from observations and models. New flexible land data assimilation systems have been developed that can assimilate a wide variety of measurements such as 2m temperature and humidity, satellite-derived surface soil wetness, satellite-derived land surface temperature and vegetation properties such as LAI. The data assimilation can also propagate the surface information into the deeper soil layers.

EXAMPLE ANALYSIS OUTPUT

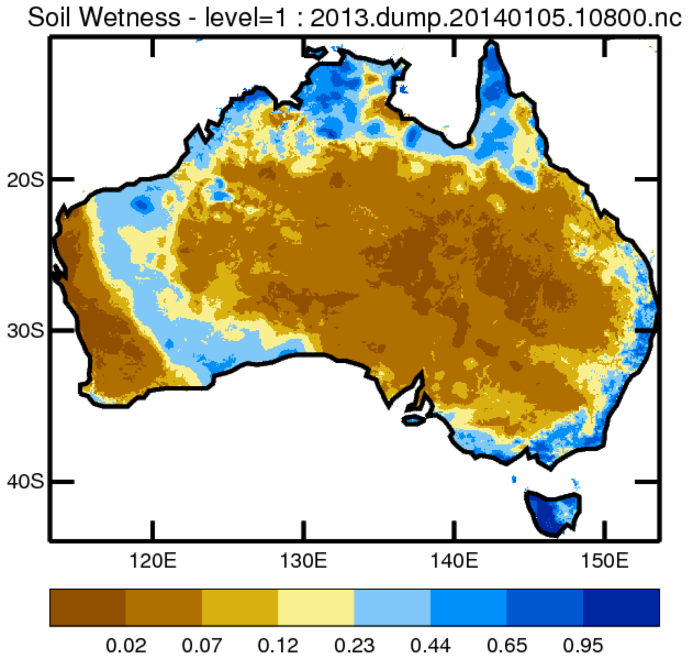
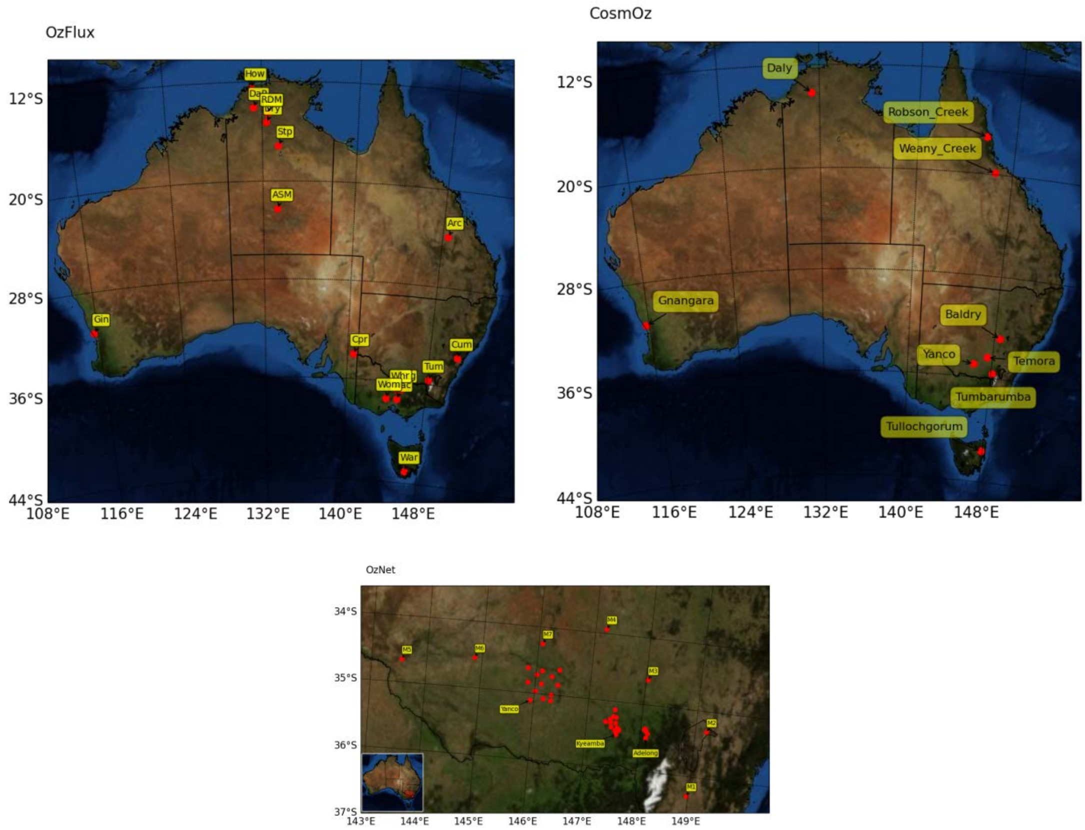


FIGURE 1. SOIL WETNESS IN THE TOP 10CM OF SOIL FOR 5/1/2014.

VERIFICATION

The high resolution soil dryness analyses are verified against in-situ soil moisture observations from the OzFlux, CosmOz and OzNet network.



CONCLUSIONS

This work presents a high resolution land dryness analysis system. Verification against in-situ observations show that this system can provide fire agencies with far more accurate information than the simple models currently used.