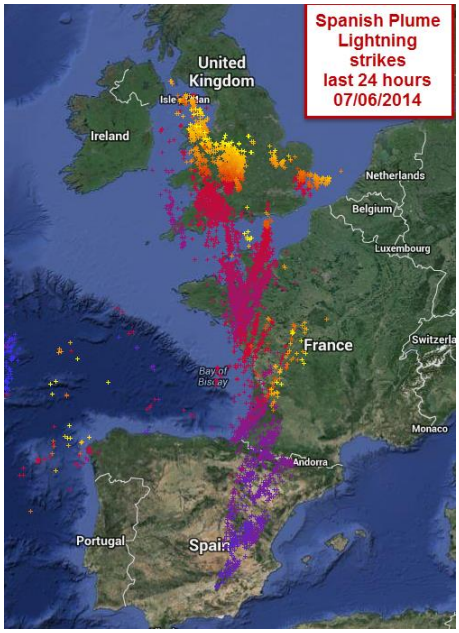
SPANISH PLUME EVENT (v1)JUNE 2014

The "Spanish Plume" forecast to arrive from Friday and into Saturday is a special weather set-up for producing thunderstorms in the UK, as seen below.



It is a rather complex weather pattern which needs some special ingredients to prime the atmosphere but also some fine tuning of local conditions to cook-up any big thunderstorms. Like all thunderstorms, Spanish Plume storms are based on **convection** which means that thermals of air can rise uninhibited through the atmosphere creating tall deep cumulonimbus clouds. Unfortunately, thunderstorm formation is notoriously difficult to forecast accurately, often being altered by local factors below the resolution of most forecast models or subtle changes in wind patterns which can subdue expected instability even up to the last moment. Some places may see a tumultuous thunderstorm of epic proportions while other places not far away will see very little impressive action or nothing at all. So an understanding of the plume might help figure out how much you can expect from any convective action forecast with a Spanish Plume event! Read below to find out the ingredients for a Spanish Plume but, if you are in a rush, then read the BBC weather summary here (it's a bit shorter!)

The large scale "synoptic" ingredient that is priming the atmosphere for the possibility of storms is a moderately deep (for June) low pressure that has arrived from a cool NW direction, and will sit in the Atlantic to the SW of the UK and west of Spain. This LOW pressure system has cool moist unstable Atlantic polar maritime air wrapped round numerous fronts. The low pressure system provides the main synoptic ingredient to kick off a Spanish Plume. It spins winds anti-clockwise around the central low and this means that, if the LOW is deep enough (which this one is for June at an unseasonable 988mb) and located in just the right place, powerful upper winds driven by a lively jetstream will reach the UK from a warm southerly direction ahead of any fronts as the LOW inches towards the UK. HIGH pressure over the Mediterranean will also help to push winds out of North Africa, over Spain, into France and finally reach Britain across the English Channel. This southerly wind is what is known as a "plume". It is characteristically a dry airmass, often loaded with Saharan dust, that arrives in the UK at relatively high levels, above around 1000m, as it rides over local boundary layer weather nearer the surface.

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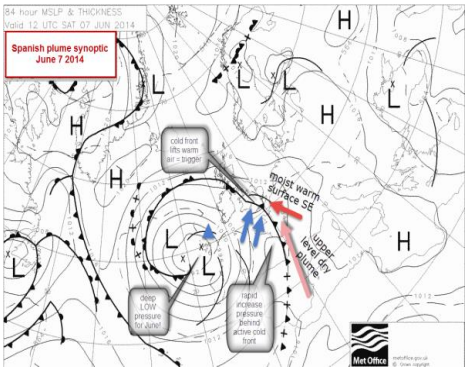
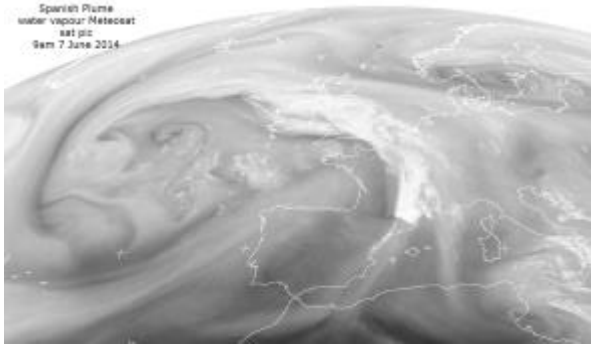
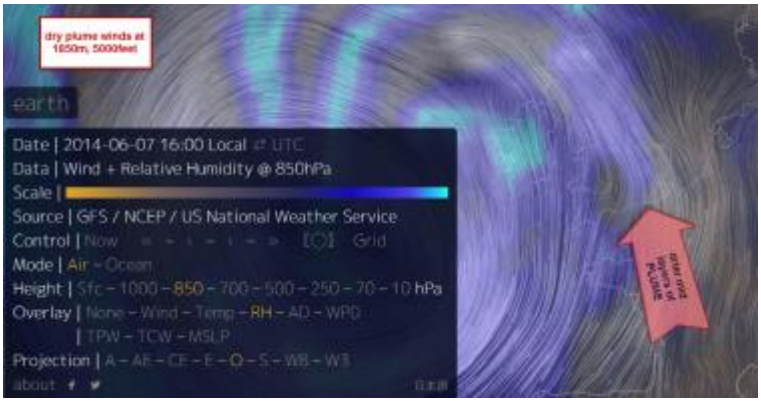
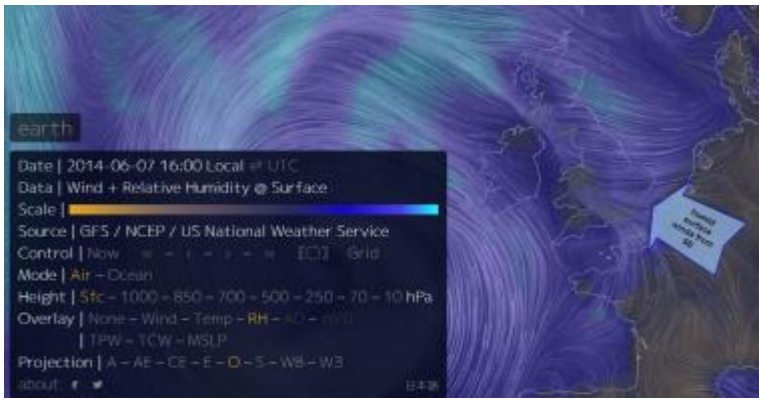
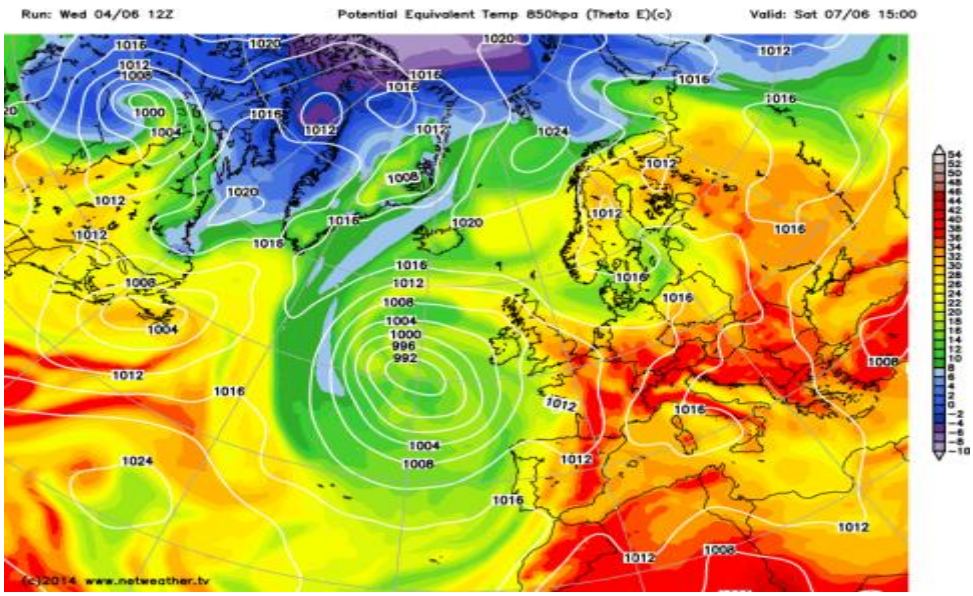








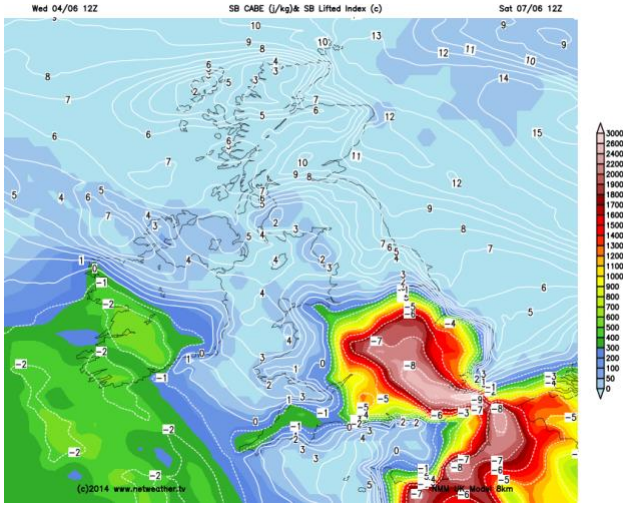


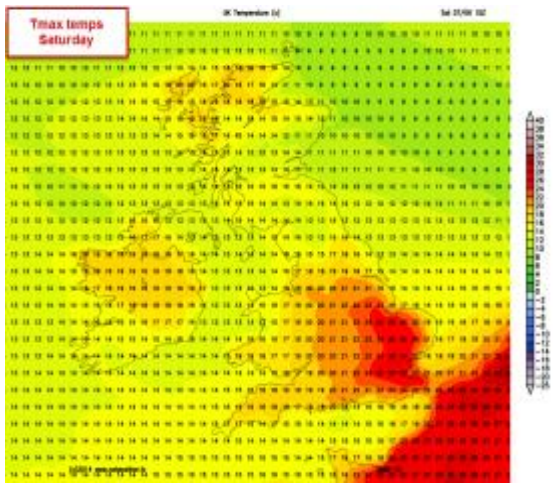
By itself, a warm dry wind wafting up from Spain will not necessarily create any big bangs. Other, smaller scale ingredients (herbs and spices if you like) are required to finally cook-up a good thunderstorm, with perhaps large hail, cg (cloud to ground) lightning and thunder and even funnel clouds or a tornado. Thunderstorm **triggers** are needed to push the air UP. Thunderstorms require some critical ingredients: heat, moisture and lift. Additionally, convergence of winds, cool or warm water bodies (the Channel), orographic influences (hills) and wind shear and any nearby FRONTS can also contribute to the thunderstorm cook-up.

Perhaps the most important factor in thunderstorm formation is TIMING. The precise arrival time and combination of unstable air masses, fronts and moisture is what makes or breaks storms. Any element that is premature or delayed can be the death of expected storm formation. The best example of this is whether unstable air arrives during a sunny warm day or at night, when surface based heating is absent. In the case of the Spanish Plume event 7 June, the unstable air arrived at night over a comparatively stable boundary layer surface air mass. The only storms that resulted were elevated thunderstorms embedded in the unstable upper air ahead of the cold front (which oddly brought warmer conditions later in the day as cloud cleared and sun came out but too late to coincide with the impressive instability of the plume).

Here is an overview of the other main **ingredients** as it applies to the Spanish Plume like the one on 7 June 2014 over the UK:

Heat! the SE of England is due to get warm or even hot on Saturday with Tmax temps well over 25c in sunny spots. This will warm the air at the surface and, like a hot air balloon, these air "parcels" will want to rise (called lift). Warm air is also being moved into the country from the south by a process called advection. Charts showing the heat energy providing the potential for air to rise are called CAPE: convective available potential energy. In the UK we are pleased with CAPE values of 200-500j/Kg for some thunderstorms. On Saturday we might expect values of up to 3000j/Kg. The other measure used to assess thunderstorm potential is the LIFTED INDEX (LI) this measures the difference in temperature between a parcel of air lifted to 5000m and the temperature of the air around it. Negative figures show the air is buoyant and ready to rise. Values of -8 or -9 are unusually low and show a very unstable airmass with the potential for plenty of lift!





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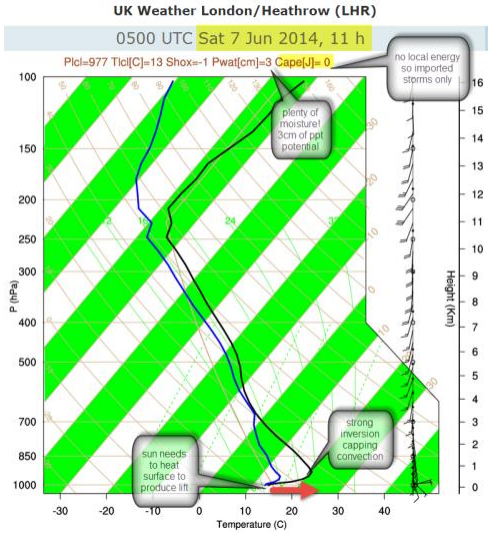
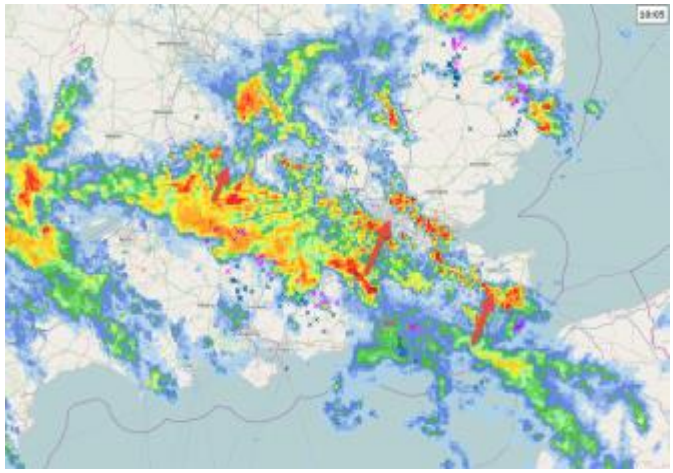
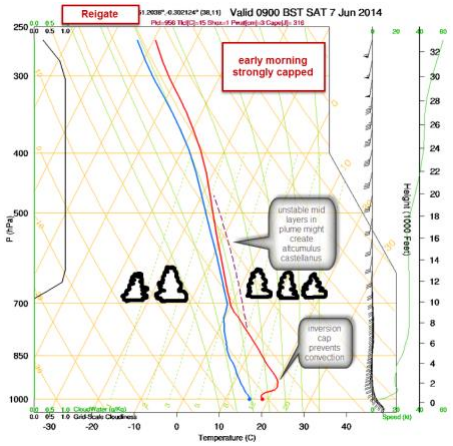
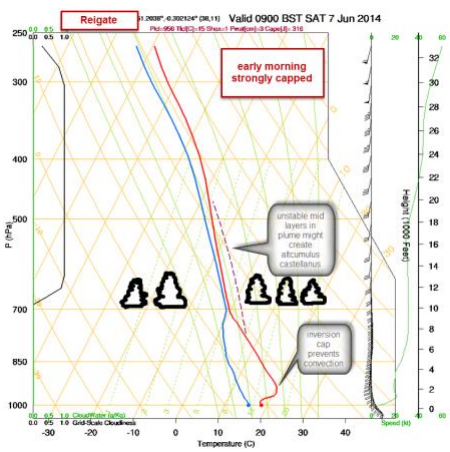
In a Spanish Plume event the upper air contains enough energy and moisture to produce elevated thunderstorms even in the absence of surface heating: this means moderate thunderstorms can occur at night and with extensive cloud cover. The morning moderate storms experienced in the SE on Saturday 7 June were all elevated thunderstorms because extensive cloud cover throughout the morning meant an absence of surface based heating to kick off more purposeful convective activity.





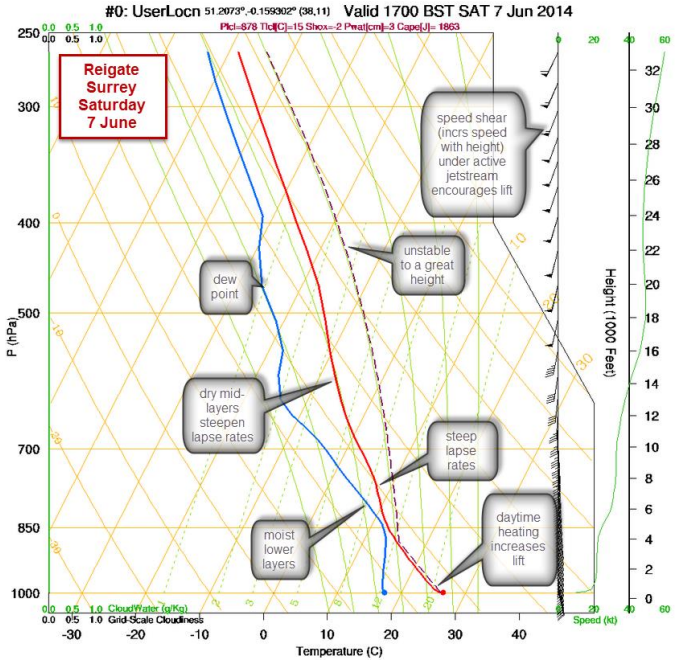
Moisture! local SE winds are set to be quite humid with a relatively high water content: high dew points illustrate this with some reaching 20c on Saturday… a muggy humid day. This moisture will be required, of course, to form clouds. To form really big clouds you need a lot of water in the atmosphere. Once water vapour starts to condense it releases latent heat and this heat gives additional lift to convection and feeds thunderstorm formation. Interestingly and perhaps counter to what might be expected, a dry plume of air mid-way up through the atmosphere is also an important ingredient to the production of big thunderstorms. Drier air at mid-levels aloft gives the atmosphere added instability for the production of thunderstorms. The reason for this is that dry air cools more rapidly with height than moist air (because rising moist air releases latent heat when clouds inevitably form and this additional heat reduces the rate of cooling of saturated air with height). The rate of cooling with height is called the "lapse rate" and the lapse rates or temperature gradient on Saturday is steep. So moisture is a critical ingredient to storm formation because it controls instability and cloud formation.





 Author: Simon Collins

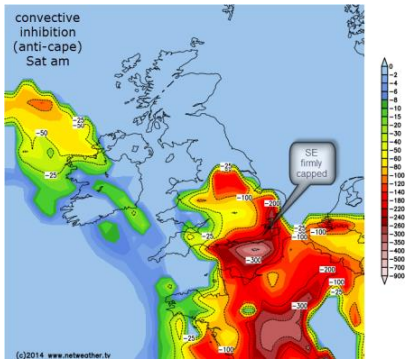
The skew-t charts show temperature change with altitude. They are called Skew-t because the temperature lines are skewed off the vertical slightly. Whilst they are initially odd to look at, focus on the red and blue and dashed lines: if the red and blue lines are close together it means the air is saturated (cloudy). If they are far apart then the air is dry. If the red line skews to the right then this is known as an inversion where temperatures can increase or stay the same with height. Such an inversion will prevent thermals rising and the formation of clouds from surface convection, a critical ingredient for big thunderstorms.

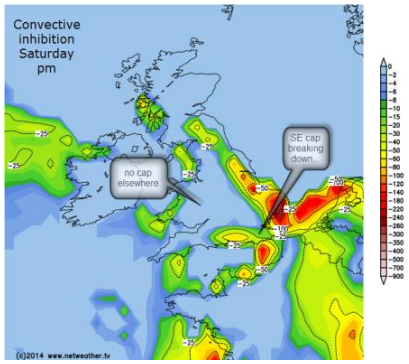


The other ingredient the skew-t chart shows above is plenty of wind shear with height, in this case speed shear. Wind shear is the change of wind speed and/or direction with height. Increasing wind speed with height has the effect of dragging air off the ground like a hoover. On Saturday there is a jetstream moving overhead during the day and this will cause divergence aloft and encourage more air to lift off the surface. Strong directional wind shear, when winds turn at angles through the atmosphere and when different winds directions meet around fronts, is also a trigger for tornadoes. The UK quite regularly has tornadic conditions in lively convective thunderstorm weather but the ingredients for tornadoes are a even more fickle! Our tornadoes are considerably less powerful than those in the USA but can be of great interest and still cause damage by uprooting trees, damaging rooves and chimneys and even tipping cars.

Lift! like a hot air balloon, a warm bubble of air will only rise if it is warmer than the air around it. On Saturday morning a CAP will exist in the atmosphere that will prevent air lifting far off the surface, thus preventing cloud formation. This cap is known as a temperature inversion and the cap on Saturday is pretty solid, so little convection is expected early on. However, during the day the sun will heat the surface and start to break down the cap. A strong cap will build energy and heat below and, if the surface heats up to a threshold then the cap can be broken, usually in the afternoon and a sudden explosive thunderstorm could be produced. In the mid-west of the USA tornado chasers call this process "busting the cap" and it produces the possibility of extreme weather.

On charts the cap is shown as convective inhibition that acts against convection. Another mechanism that is capable of lifting air rapidly is the proximity of fronts which can mechanically lift the air as airmasses converge. On Saturday a slow moving cold front is forecast to be located along a north/south axis through the Midlands and S England, moving gradually east… this could be the focus of most activity if the cap remains solid further east.





Convergence of winds! winds converging at the surface are another local or regional factor that enhances convection. Converging winds at the surface tend to slow down and pile up, like lorries slowing down uphill and causing congestion. When surface winds pile into each other (converge) they can only go one way… UP! Convergence often occurs at the coast where winds coming from the sea slow down due to friction over the land. This is one reason why the south coast often produces thunderstorms or enhances them as they cross the Channel (so long as the Channel sea surface temperature is warm enough – another story!). The other map below shows areas where there is a sufficient combination of wind shear, heating and energy to possibly start to rotate a thunderstorm: rotating thunderstorms are called supercells and are capable of producing tornadoes. These are the "big daddy" of thunderstorm cells and would be an awesome site for anyone able to catch a photo before or after the inevitable heavy rain, hail, lightning, darkening skies and thunder!

Even with so many ingredients primed for thundery weather in the SE on Saturday it still remains a risk potential rather than a certainty. Local factors might inhibit convection, too much cloud in the morning could reduce surface heating and the cap may not be broken, so no thunderstorms! It's a matter of waiting to see the conditions nearer the time to make a final forecast and often it remains uncertain until the very day. Nevertheless, there is a possibility of explosive convective thunderstorm action on Saturday, mostly in the Midlands and the East, if the CAP is BUST! If this occurs then instability of the atmosphere will rapidly build extremely tall cumulonimbus clouds up to 10,000 metres tall. The UKMO issued an uncharacteristically early warning of heavy rain for Saturday on the basis of this Spanish Plume event.

Although an accurate forecast is beyond the scope of this article and best left to the professionals, one broad indicator of possible storm pattern over the course of the day is set by convergence of winds and the likely position of the front as it progresses west to N/east. The first plume of instability arrives in N France later on Friday and some might arrive S England Friday pm with low risk thunderstorm activity imported across the Channel from France (as it happened this occurred only in the SW). The charts for Saturday below show how the main location of biggest storm activity could move

broadly from west to NE during Saturday and clear off into the N Sea overnight. (as it happened the front moved much quicker and clear S England and most parts of Central England by lunchtime leaving a bright afternoon with bubbly Cu).